Corrugated Bars

FOR

Reinforced Concrete Construction

1908

EXPANDED METAL AND CORRUGATED BAR CO.

7219

Corrugated Bars

1908

Corrugated Bars

FOR

Reinforced Concrete Construction

STRENGTH
PERMANENCE

1908

SIMPLICITY
ECONOMY

EXPANDED METAL AND CORRUGATED BAR CO.

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EXPANDED METAL AND CORRUGATED BAR CO.

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ST. LOUIS

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Consulting Engineer.

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Company Engineer.

R. L. MURPHY,
Contracting Engineer.

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E. J. CHIBAS, C. E. . . . . Santiago, Cuba
WM. G. MOLER . . . . Apartado 289, City of Mexico, Mexico

ASSOCIATED COMPANIES

CANADA: CORRUGATED STEEL BAR CO., OF CANADA, Ltd., Coristine Building, Montreal

FRANCE: LA BARRE CRÉNELÉE, 51 Rue Du Faubourg, Poissionniere, Paris, France

BELGIUM: SOCIÉTÉ ANONYME d'OUGRÉE—MARIHAYE, à Ougrée (Belgique)

ITALY: SOCIÉTÉ ANONIMA FERRIERE PIEMONTESI (Anciennement Vandel & Cie), à Avigliana (Italie)

GREAT BRITAIN: PATENT INDENTED STEEL BAR CO., Ltd., Queen Anne's Chambers, Westminster, London, S. W.

A NUMBER of experiments have been made during the past year to determine the strength and permanence of reinforced concrete under conditions calculated to produce fatigue effects and develop inherent weaknesses through repetition or prolonged action of loads. This is a most desirable field for research, and the work already accomplished has resulted in a fuller appreciation of the importance of the question of bond between the concrete and the reinforcement.

Whatever stress exists in the reinforcing bars is necessarily put into them through bond action with the concrete, and it is imperative that the bond be not only of sufficient strength to develop the requisite stresses but also of such a nature *that the permanence of the connection may be assured.* All considerations indicate the desirability, or rather necessity, of using a mechanical bond bar to bring about the necessary state of intimate stress relationship.

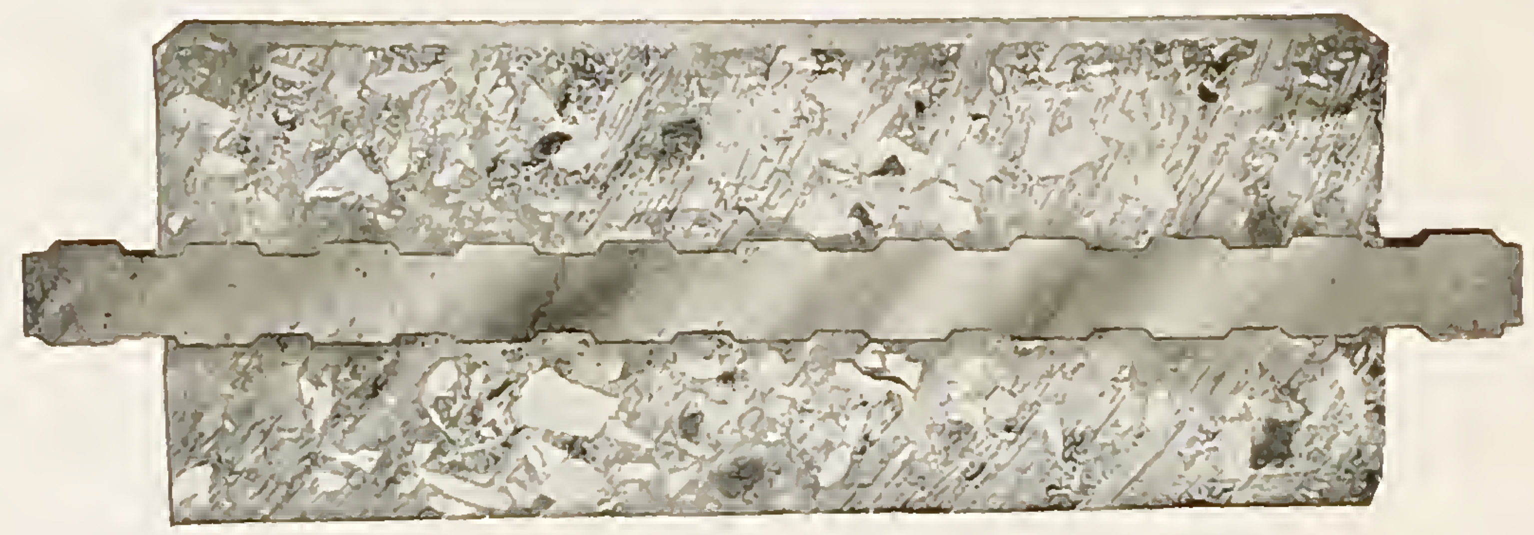
What is a "mechanical bond bar?"

Is it some form of smooth bar, twisted or otherwise deformed, which depends, nevertheless, entirely upon surface adhesion for its *initial bonding strength*, and which will accordingly slip somewhat at very low unit stresses before it binds or wedges in the concrete?

Or is it such a one as the Corrugated Bar, with square shoulders, at frequent intervals along its length, which come into action *immediately* upon the application of stress, and develop their full efficiency with absolutely no movement?

We will assume your reply and endeavor to bring out some of the especial features of the Corrugated Bar.

Corrugated Bar Bond. The following illustration shows the simple and positive bond of the Corrugated Bar. The whole theory of ferro-concrete construction is based on the proper working together of the two materials, and it is difficult to imagine how this could be better brought about than by the continuous mechanical interlocking shown.



Economy of the Corrugated Bar. Notwithstanding its positive bond, there is no excess material in the New Style Corrugated Square, the metal is so disposed that it is all available for tensile strength. Every ounce of metal you buy adds directly to the strength of the structure.

Adhesion is Unreliable. The experienced engineer and architect realizes that adhesion (by which is meant the sticking together of the concrete and steel, which alone bonds them together when plain or smooth bars are used) is a very uncertain quantity, and avoids any doubt as to the stability and permanence of the structure he has under consideration, by insisting upon the use of a mechanical bond bar. The very stress to which the reinforcement is subjected when the structure is loaded tends to destroy adhesion, owing to the consequent reduction in cross section of the bar, when plain bars, or patented bars of smooth surface, are used. Moving loads, causing shocks or vibration, have also their effect in destroying adhesion, and it has been shown that the adhesion of concrete to metal may be greatly reduced by the action of water alone. None of these causes can affect the bond of the Corrugated Bar, which is absolutely independent of mere surface adhesion.

Permanence Depends on Bond. The permanence of the structure depends on the positive protection of the reinforcement from corroding influences, and a reinforcing bar that will prevent all local slipping and consequent large cracks, is necessary, if the work is to be considered of a permanent character.

High Elastic Limit Results in Great Load Carrying Capacity. The strength of a reinforced concrete beam is reached when the steel has been stretched to its yield point, and it is therefore desirable to have this limit as high as is consistent with the requisite ductility. The higher the elastic limit of the steel the greater will be the load carrying capacity of the beam per pound of metal.

Economy of Material. Corrugated Bars have an elastic limit of between 50,000 and 65,000 pounds per square inch, while ordinary commercial medium steel has a limit of about 33,000 pounds per square inch. In the light of the foregoing remarks, it is evident that the Corrugated Bar has a great advantage as regards strength and permanence and economy over commercial steel bars.

Advantages of the Corrugated Bar. The Corrugated Bar has the following points of advantage over other forms of bar reinforcement:

A definite mechanical bond independent of surface adhesion.

No excess metal for bond only in New Style Corrugated Squares.

Full utilization of the strength of the steel up to its elastic limit, owing to the perfect bond.

These features in connection with the high elastic limit result in

Saving in material.

Increase in factor of safety.

Design of Work. The Expanded Metal & Corrugated Bar Company maintains an engineering department for the benefit of those contemplating reinforced concrete construction. The services of their engineers are at your command, and any information as to design or construction will be given to those requesting it. Detailed drawings and estimates will be furnished, if desired, for those constructions in which the Corrugated Bar is used.

STANDARD SIZES AND TYPES OF CORRUGATED BARS.

Corrugated Bars are rolled to the sizes and weights illustrated on the following pages and are of four types, as follows:

Corrugated Rounds, shown on page 7.
Corrugated Squares, New Style, shown on page 8.
Corrugated Squares, Old Style, shown on page 9.
Corrugated Flats, Universal Type, shown on page 10.

Particular attention is called to our Corrugated Rounds which we are placing upon the market this year. This section has been designed to meet the requirements of those who, for various reasons, prefer a round bar. The details are carefully arranged so as to secure maximum efficiency of material, and we present this latest type of Corrugated Bar with confidence.

Unless otherwise specified we furnish Corrugated Bars rolled from a high elastic limit steel, with a yield point of 50,000 pounds or over. We are prepared, however, to roll any grade of steel desired, and can supply Corrugated Bars to meet special requirements as to elastic limit, from open hearth or Bessemer stock.

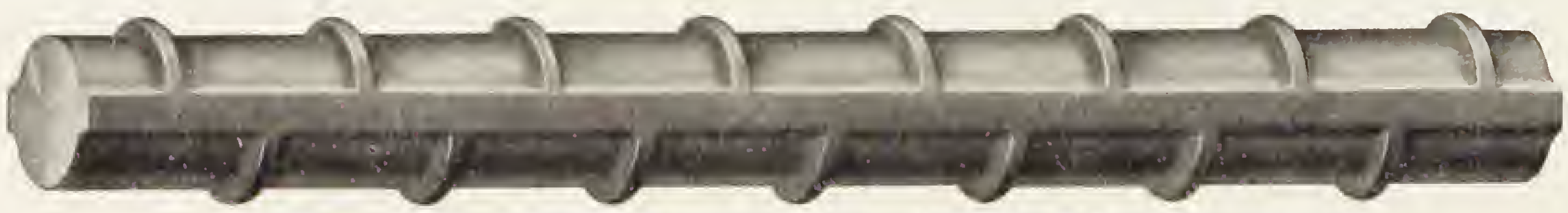
We furnish these bars cut to your specifications, and can make prompt shipments from stock or mill. Corrugated Bars are rolled at five mills in different parts of the country, thus affording exceptional advantages as regards deliveries. We have warehouses and carry large stocks of Corrugated Bars, for immediate delivery, in the following cities: Pittsburg, Boston, Philadelphia, Chicago, St. Louis, New Orleans, San Francisco, Portland and Seattle.

$\frac{3}{8}$″ Bar. Net Section 0.11 sq. in.; Weight 0.38 lb. per ft.

$\frac{1}{2}$″ Bar. Net Section 0.19 sq. in.; Weight 0.66 lb. per ft.

$\frac{5}{8}$″ Bar. Net Section 0.30 sq. in.; Weight 1.05 lbs. per ft.

$\frac{3}{4}$″ Bar. Net Section 0.44 sq. in.; Weight 1.52 lbs. per ft.



$\frac{7}{8}$″ Bar. Net Section 0.60 sq. in.; Weight 2.06 lbs. per ft.

1″ Bar. Net Section 0.78 sq. in.; Weight 2.69 lbs. per ft.

$1\frac{1}{8}$″ Bar. Net Section 0.99 sq. in.; Weight 3.41 lbs. per ft.

$1\frac{1}{4}$″ Bar. Net Section 1.22 sq. in.; Weight 4.21 lbs. per ft.

CORRUGATED ROUNDS.

A variation in weight of 5 per cent either way is required.

¼″ Bar. Net Section 0.06 sq. in; Weight 0.24 lbs. per ft.

⅓″ Bar. Net Section 0.11 sq. in.; Weight 0.38 lbs. per ft.

⅜″ Bar. Net Section 0.14 sq. in.; Weight 0.48 lbs. per ft.

½″ Bar. Net Section 0.25 sq. in.; Weight 0.85 lbs. per ft.

⅝″ Bar. Net Section 0.39 sq. in.; Weight 1.33 lbs. per ft.

¾″ Bar. Net Section 0.56 sq. in.; Weight 1.91 lbs. per ft.

⅞″ Bar. Net Section 0.77 sq. in.; Weight 2.60 lbs. per ft.

1″ Bar. Net Section 1.00 sq. in.; Weight 3.40 lbs. per ft.

1¼″ Bar. Net Section 1.56 sq. in.; Weight 5.31 lbs. per ft.

CORRUGATED SQUARES, NEW STYLE.

A variation in weight of 5 per cent either way is required.

½″ Bar. Net Section 0.18 sq. in.; Weight 0.64 lb. per ft.

¾″ Bar. Net Section 0.37 sq. in.; Weight 1.35 lbs. per ft.

⅞″ Bar. Net Section 0.55 sq. in.; Weight 1.95 lbs. per ft.

1″ Bar. Net Section 0.70 sq. in.; Weight 2.70 lbs. per ft.

1¼″ Bar. Net Section 1.07 sq. in.; Weight 4.00 lbs. per ft.

CORRUGATED SQUARES, OLD STYLE.

A variation in weight of 5 per cent either way is required.

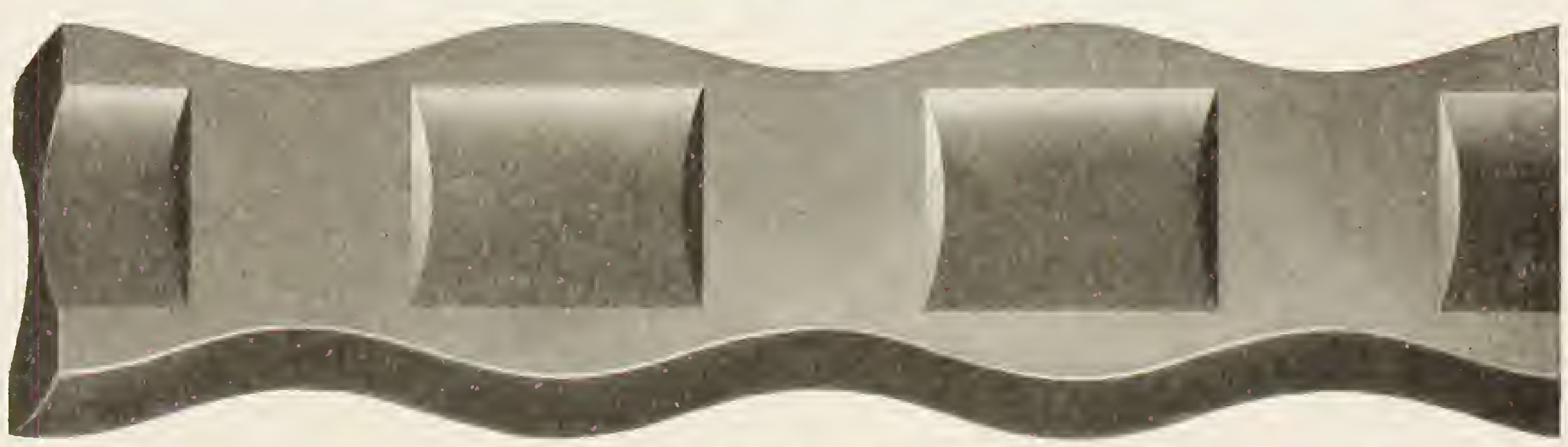
No. 1, $\frac{1}{4}''$x1″ Bar. Net Section 0.19 sq. in.; Weight 0.73 lb. per ft.

No. 2, $\frac{5}{16}''$x$1\frac{1}{4}''$ Bar. Net Section 0.32 sq. in.; Weight 1.18 lbs. per ft.

No. 3, $\frac{3}{8}''$x$1\frac{3}{8}''$ Bar. Net Section 0.41 sq. in.; Weight 1.35 lbs. per ft.

No. 4, $\frac{3}{8}''$x$1\frac{3}{4}''$ Bar. Net Section 0.54 sq. in.; Weight 1.97 lbs. per ft.

No. 5, $\frac{3}{8}''$x2″ Bar. Net Section 0.65 sq. in.; Weight 2.27 lbs. per ft.



No. 6, $\frac{3}{8}''$x$2\frac{1}{2}''$ Bar. Net Section 0.80 sq. in.; Weight 2.85 lbs. per ft.

CORRUGATED FLATS, UNIVERSAL TYPE.

A variation in weight of 5 per cent either way is required. Larger sections can be rolled if desired.

Building Construction.

IT is hardly necessary to call attention to the general and rapidly increasing use of reinforced concrete for all classes of buildings. Warehouses, office buildings, and factories all lend themselves to this construction, as in fact does any structure where durability, strength, and a low fire risk are desired. The Corrugated Bar adapts itself to building work admirably, and appeals to architects and engineers by reason of its simplicity and straightforward way of attacking the problem. The economy and security attained when the Corrugated Bar is used are also strong factors with the owner as well as with the contractor.

In the succeeding pages will be found details of floor construction applicable to all types of buildings, and some information regarding reinforced concrete foundations and extended footings.

The illustrations following are meant to convey some idea of the application of concrete, reinforced with the Corrugated Bar, to building construction.

THE BUREAU OF BUILDINGS,

OFFICE OF SUPERINTENDENT

FOR THE BOROUGH OF MANHATTAN

No 220 FOURTH AVENUE.

S.W. CORNER 18TH ST.

BY

The City of New York, Dec. 30, 1905.

Messrs. H. C. Miller & Co.,
1 Madison Av., City.

Gentlemen:-

As a result of the fire and water tests on Dec. 26th, 1905, under the supervision of this Bureau, your form of reinforced concrete construction, known as the Corrugated Bar System, is approved for general use in the Borough of Manhattan, as a fireproof construction.

This approval is issued in accordance with the Regulations of this Bureau, and on condition that such construction is made in accordance with these Regulations, and such construction and the strength of the same is determined in accordance with these rules and regulations;

Further, that all steel used in the construction shall be surrounded on all sides with at least one inch of concrete in the slab construction and at least one and one-half inches in the beam, girder and column construction;

Further, that no column used in this construction shall be less than ten inches;

Further, that the minimum thickness of slab and floor construction shall be three and one-half inches.

Your reinforced cinder construction as tested is approved for general use in the Borough of Manhattan, as a fireproof floor construction, for spans up to eight feet and live loads of one hundred and fifty pounds per square foot, provided it is constructed as tested and in accordance with the specifications on file in this Bureau. A detail of the construction, as approved by this Bureau, is enclosed herewith.

Yours truly,

Isaac A. Hopper

Superintendent

(Enclosure)

Department of Public Safety
Bureau of Building Inspection
Rooms 313-315-317-319,
Director
Chief of Bureau
City Hall,
Philadelphia, Feb. 6, 1906.

Messrs. H. C. Miller & Co.,
c/o Walter Loring Webb,
Phila.

Dear Sirs:-

The fire and water test conducted by Prof. Francis C. Van Dyke, Ph.D., at New Brunswick, N. J.. on Dec. 26th, 1905, and witnessed by an inspector from this Bureau, is accepted by the same as a satisfactory reinforced concrete fireproof construction, and is approved for general use in the City of Phila.

This however is given upon the condition that all floors shall comply with the regulations of this Bureau and the construction and strength of same is to be determined in accordance with these Rules and Regulations.

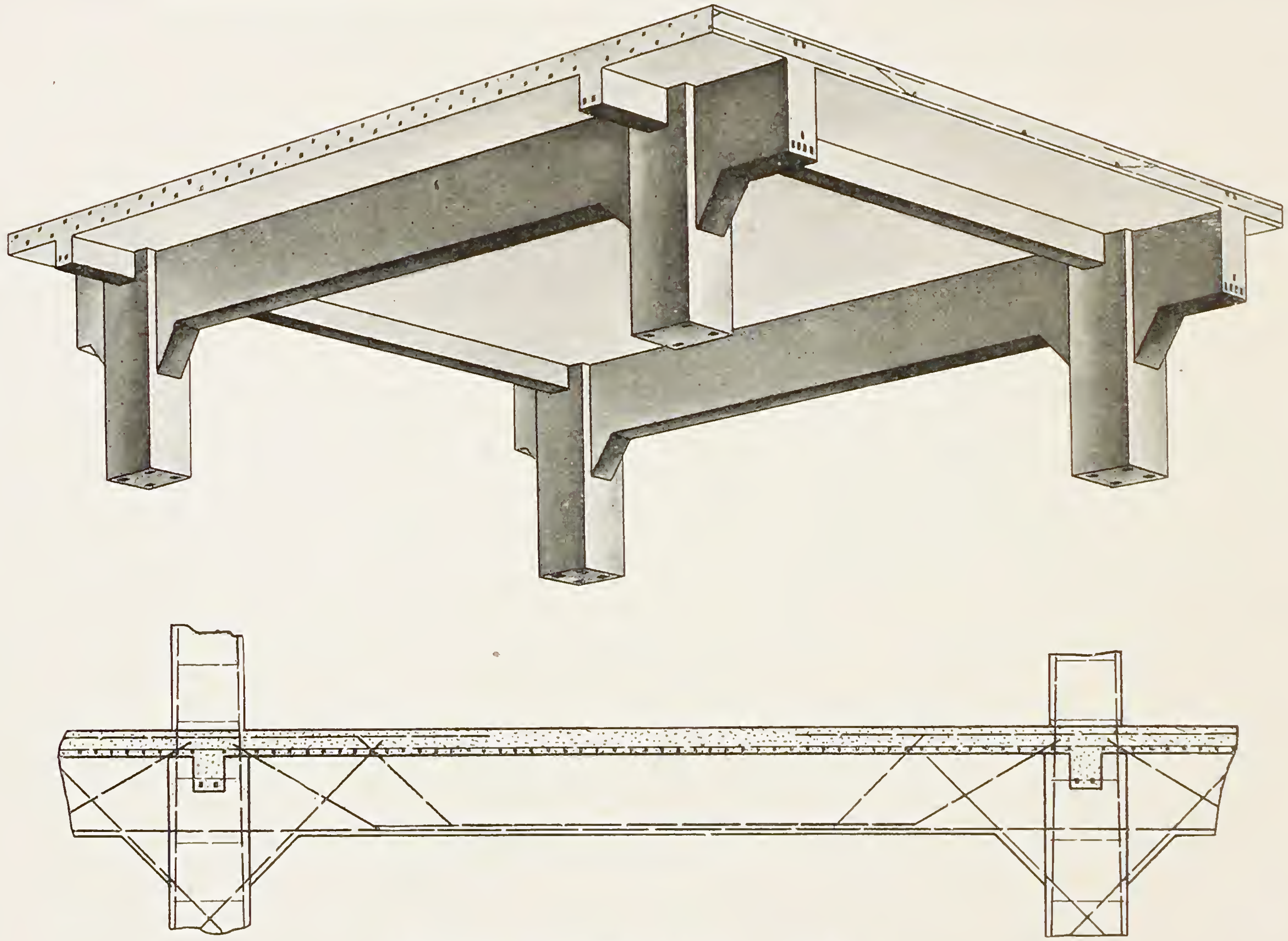
Yours truly

Edwin Clark
Chief

OFFICIAL TEST BY THE BRITISH FIRE PREVENTION COMMITTEE.

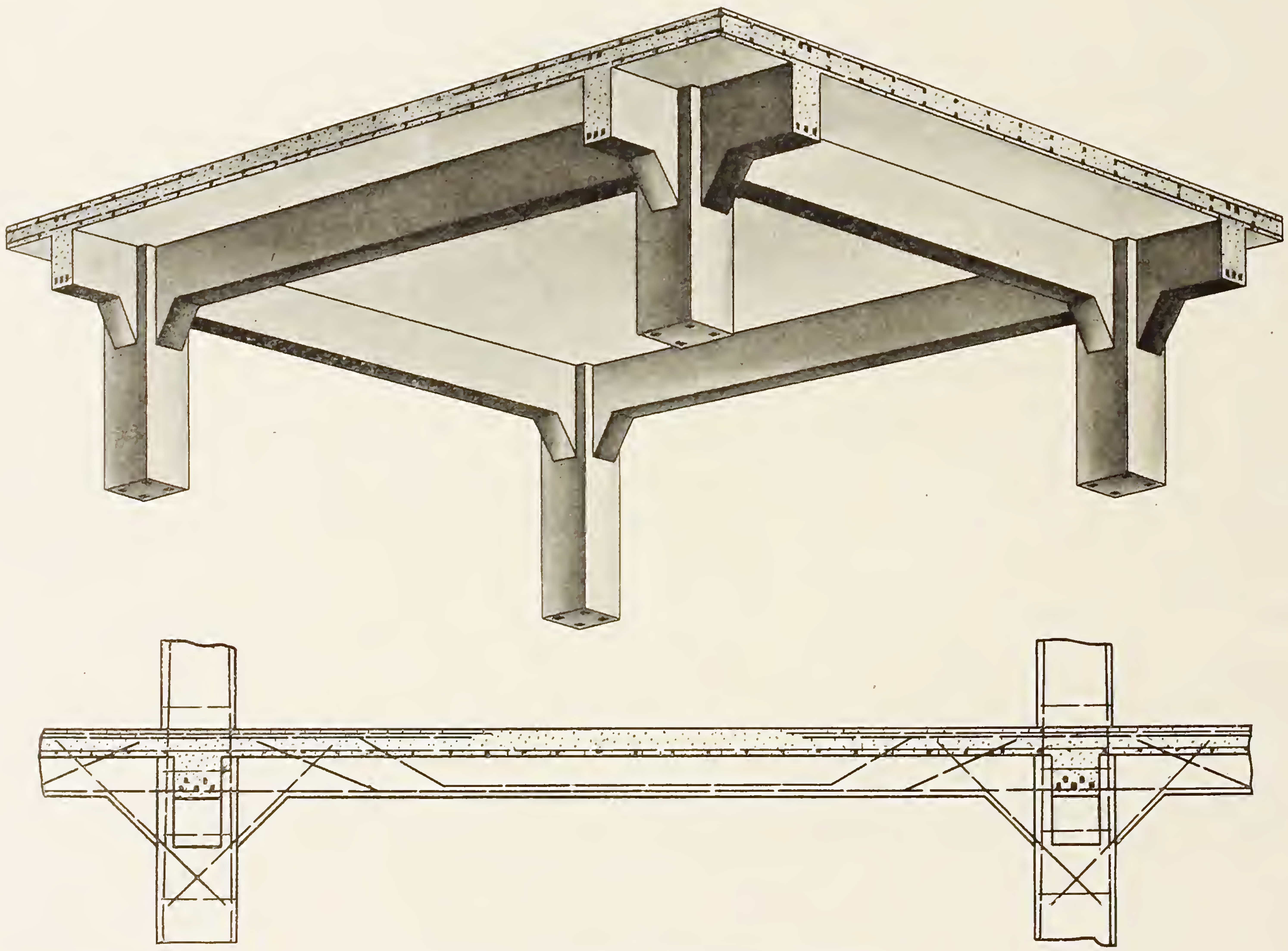
A test was made in London, July 25, 1906, under the direction of the British Fire Prevention Committee, to record the effect of a fire of four hours duration; (the temperature to reach 1800° F.) followed by the application of water for five minutes, on a Corrugated Bar Floor Construction, when carrying a load of 280 pounds per square foot. As the result of the test the **highest classification, "Full Protection, Class B" was attained.**

See Red Books of the British Fire Prevention Committee, No. 114.



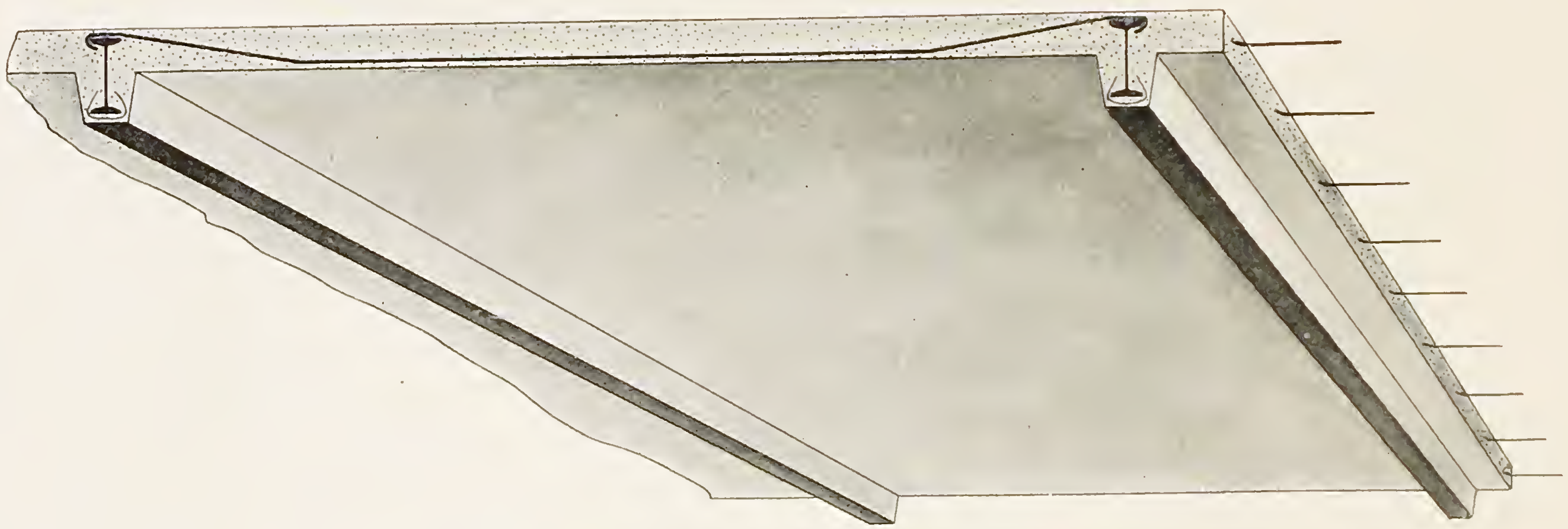
FLOOR CONSTRUCTION. TYPE A.

Flat slab, all concrete design, reinforced in one direction only. Suitable for spans up to sixteen feet; for greater spans a ribbed construction will generally be found preferable. For designing tables, see pages 108 and 109.

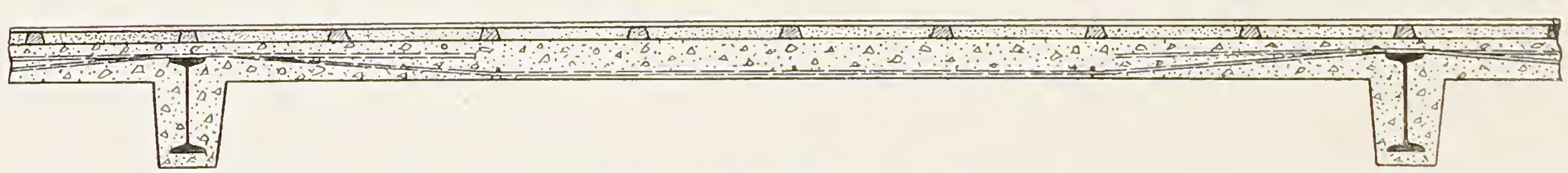


FLOOR CONSTRUCTION. TYPE B.

Flat slab, all concrete design, reinforced in both directions. Suitable for square panels and spans up to twenty feet. Special designs are necessary for this type of floor.

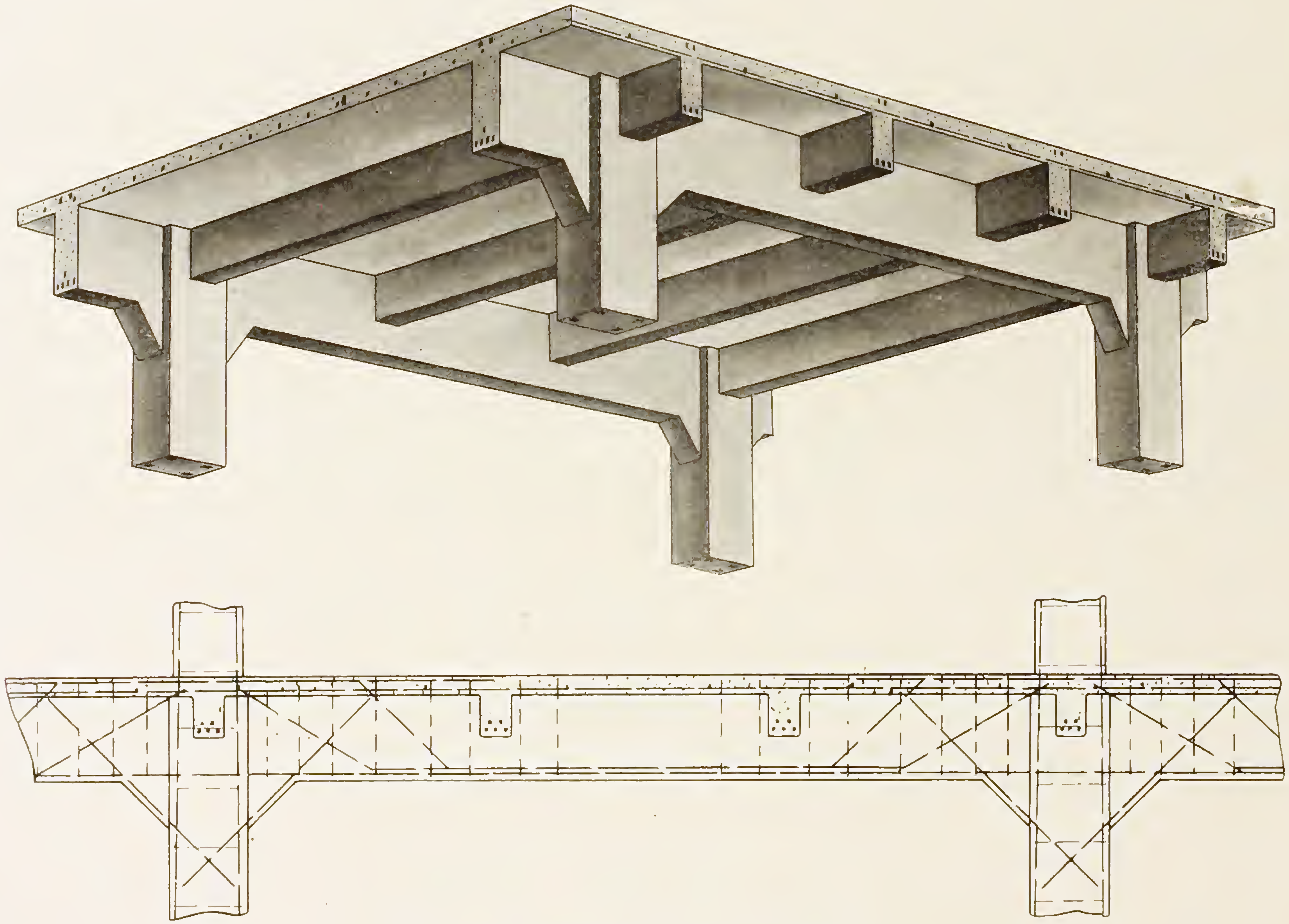


Bars may be either hooked over I-beams or extended into next panel as shown.



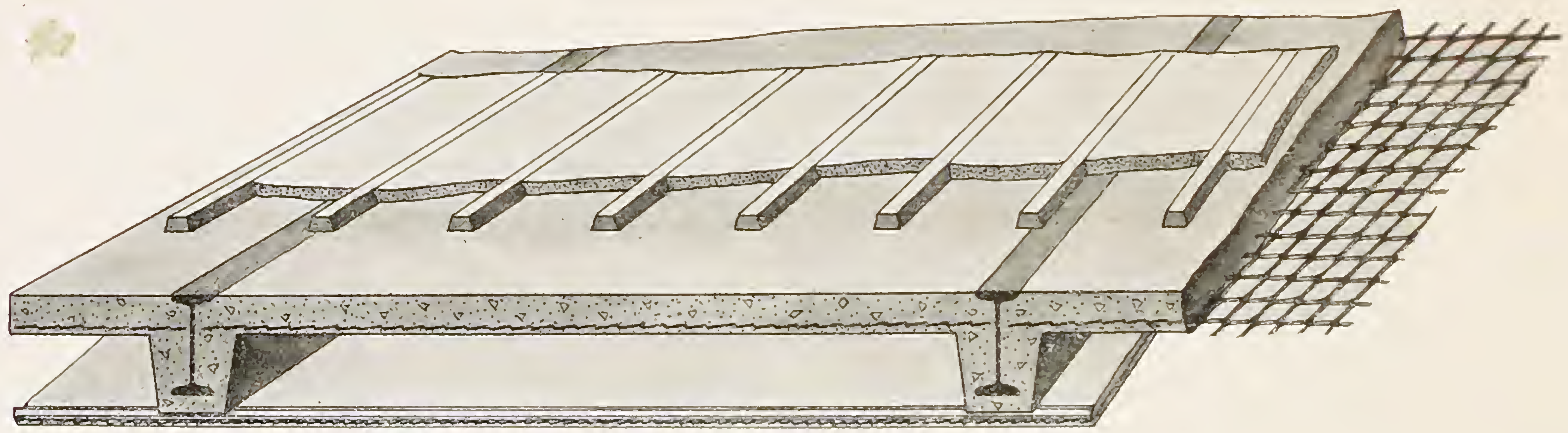
FLOOR CONSTRUCTION. TYPE C.

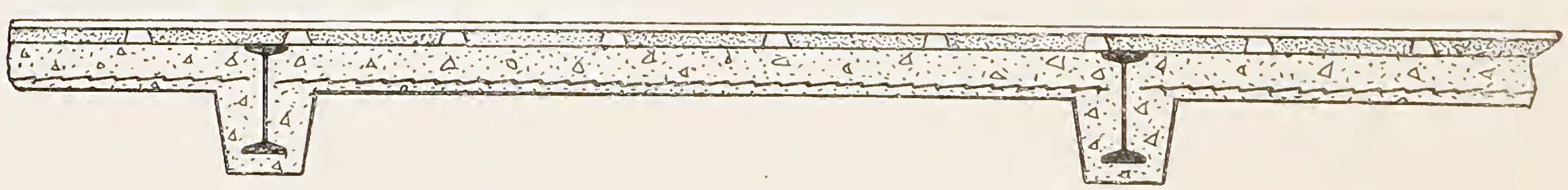
Flat slab design for steel frame construction. Suitable for spans up to sixteen feet; for greater spans a ribbed construction will generally be found preferable. For designing tables, in rock or cinder concrete, see pages 108, 109 and 110.



FLOOR CONSTRUCTION. TYPE D.

Ribbed design, all concrete construction. Suitable for spans over fourteen feet. For designing, use tables for beams and slabs.





FLOOR CONSTRUCTION. TYPE E.

Flat slab, expanded metal design, for steel frame construction. Suitable for spans up to eight feet; this type may also be used in all-concrete construction.

For designing tables in rock or cinder concrete, see page 110.

Foundations.

THE foundations are the most important part of any structure, and special care should be used in their designing. In cases where poor soil or heavy loads require extended footings or possibly a raft over the entire site, reinforced concrete construction will be found to be peculiarly suitable. Great concentrations of loading and resulting heavy shearing stresses necessitate the use of a mechanical bond bar in this class of work. The Corrugated Bar has greater bonding value than any other bar on the market, and in addition, water (and most footings are more or less subjected to its action) does not affect its bond with the concrete.

For isolated column footings, where considerable spread is required, a reinforced concrete design is more economical than either a stepped concrete pier or an I-beam grillage. An isolated column footing used in the Syndicate Trust Building, St. Louis, is shown in figure 1, on the following page. This footing, while 16 feet square and carrying a load of 580 tons, is but 3 feet thick.

An example of a double footing used in The Times Building, St. Louis, is shown in Figure 2. In this case the center line of the wall column is but 16 inches back from the property line, and it was necessary to use a "cantilever" arrangement. The dimensions of the footing were so chosen that its geometrical center of gravity coincided with the resultant of the column loads, thus insuring a uniform soil pressure. The footing was figured as a plate supported by the column bases, and subjected to the upward pressure of the earth. The simplicity of this design as compared with the ordinary steel girder cantilever construction is to be noted.

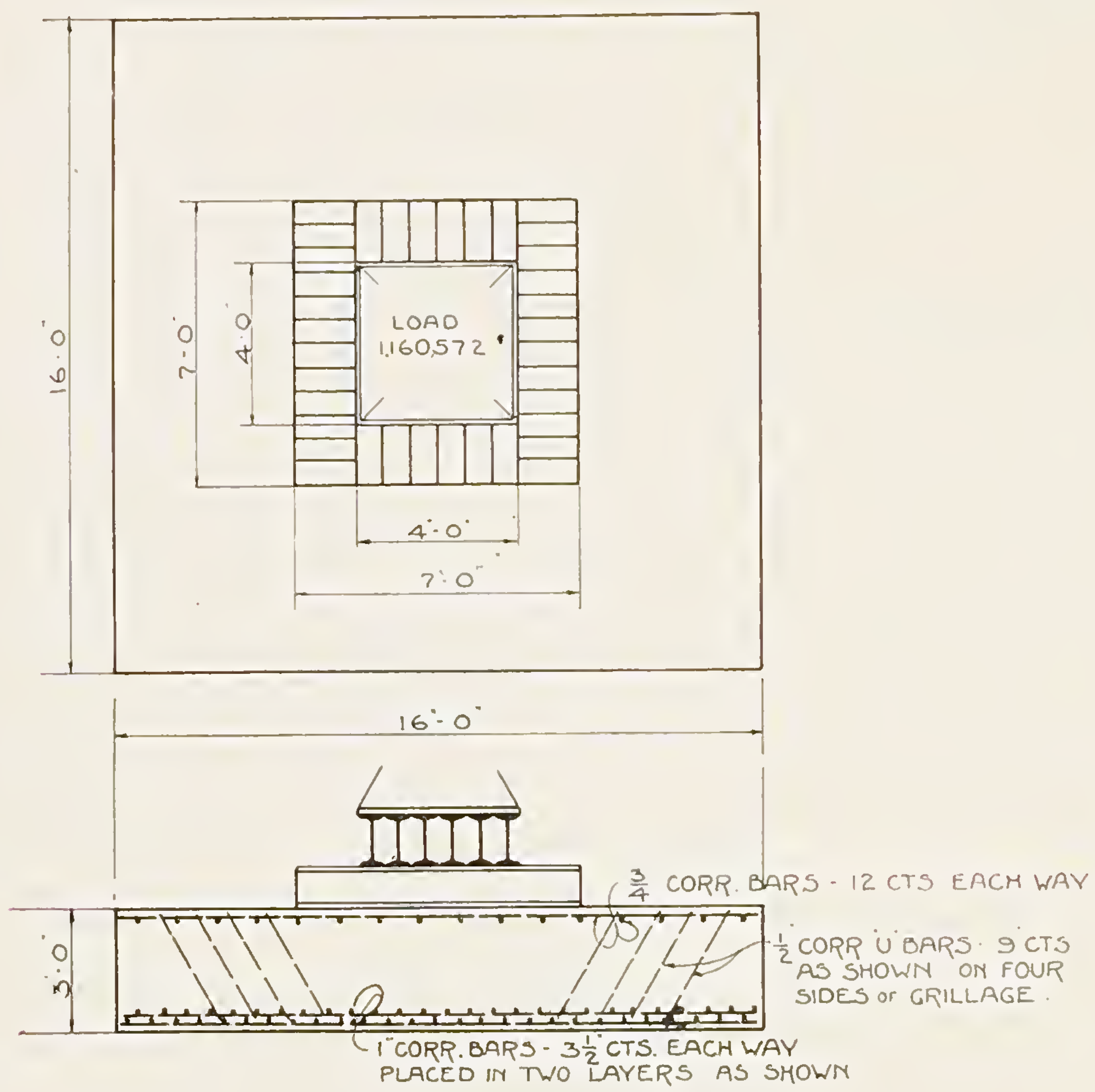


FIGURE 1.

TYPICAL COLUMN FOOTING, SYNDICATE TRUST BUILDING, ST. LOUIS.

H. F. ROACH Architect.

HILL-O'MEARA CONSTRUCTION CO., Contractors.

This building is seventeen stories high, with columns 25'x25' on centers. Load on footing, 580 tons.

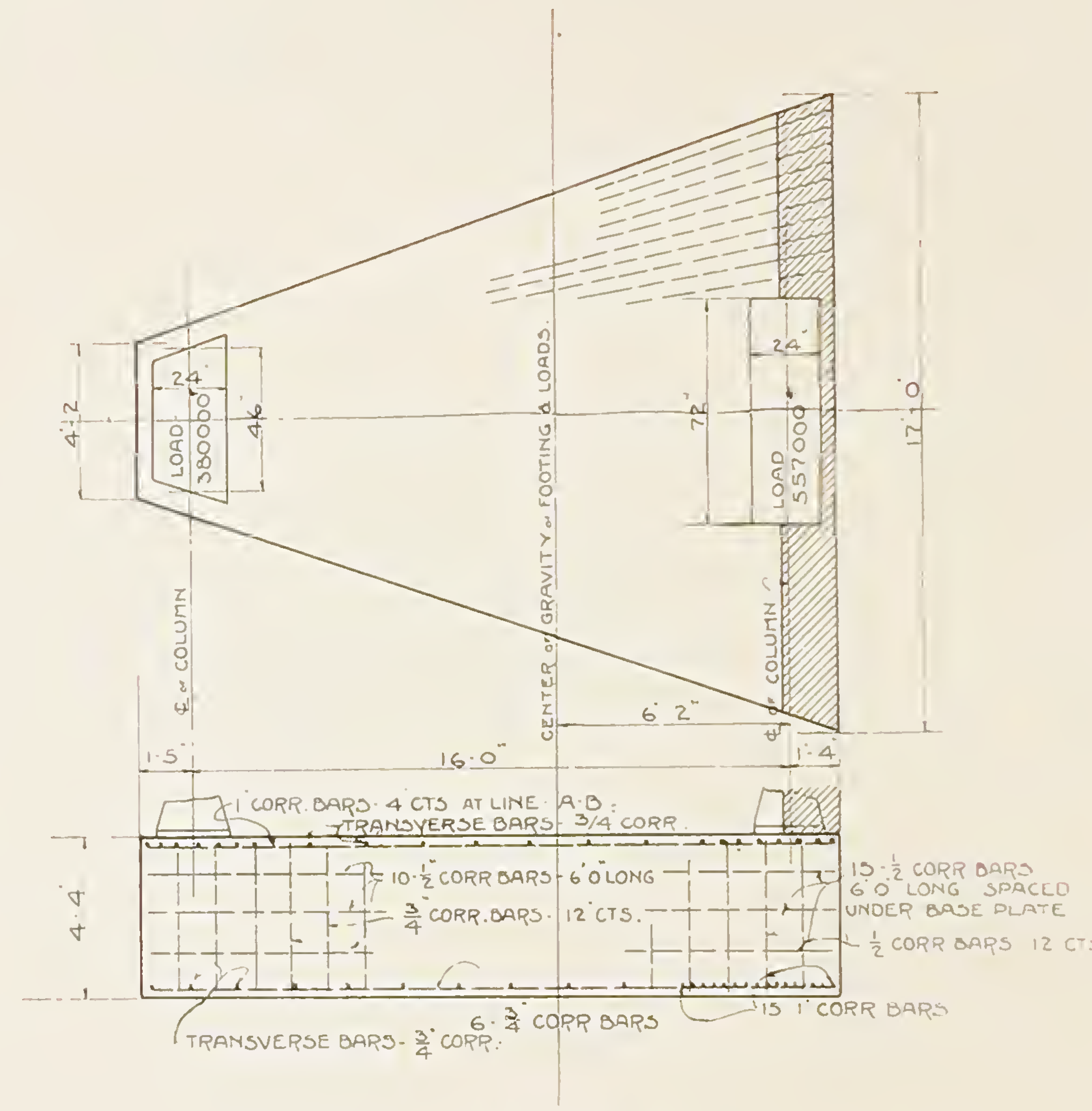


FIGURE 2.

FOOTING FOR TWO COLUMNS, THE TIMES BUILDING, ST. LOUIS.

H. F. ROACH, Architect.

W. RUS SAMUEL CONSTRUCTION CO., Contractors.

This footing illustrates the simplicity of a reinforced concrete cantilever design as compared with the construction when steel beams are used. The economy over the steel construction is obvious.

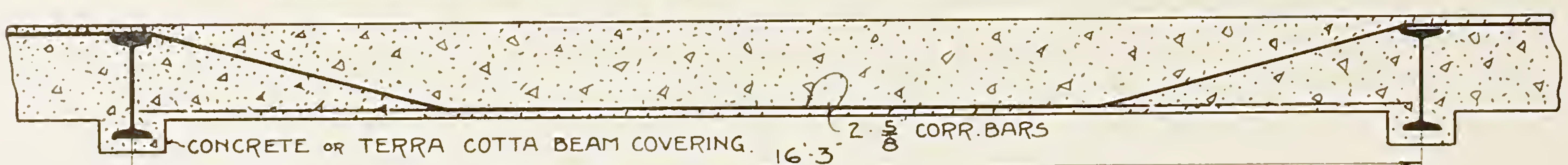
STORE AND OFFICE BUILDING FOR THE BISHOP ESTATE, NEW YORK CITY.

ERNEST FLAGG, Architect.

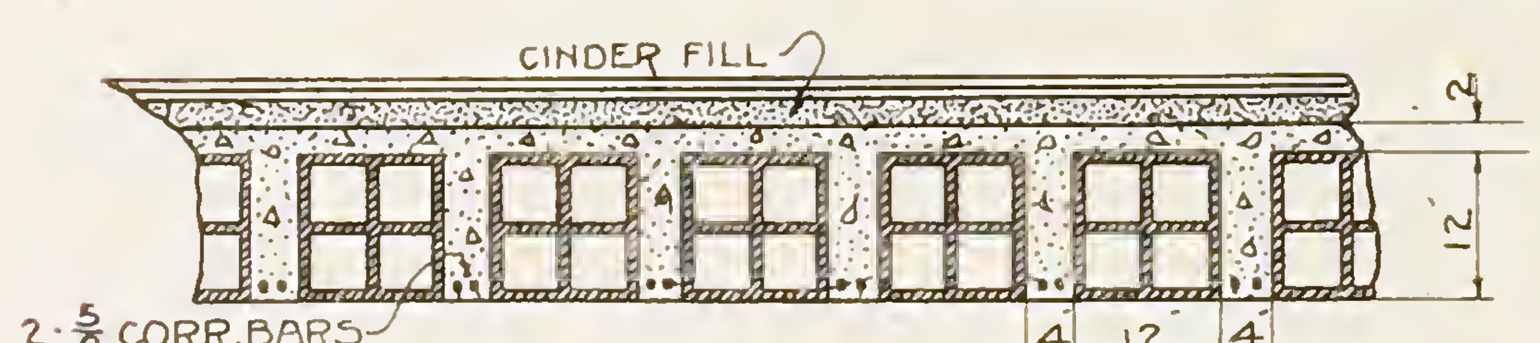
NATIONAL FIREPROOFING CO., Contractor for Floors.

This is a steel frame building with fire-proof floors of reinforced concrete, hollow tile construction.

Total floor area 53,000 sq. feet.



LONGITUDINAL SECTION THRO BEAM



TRANSVERSE SECTION

FLOOR CONSTRUCTION
BISHOP BUILDING
NEW YORK

H. C. MILLER & CO. ENGINEERS.

BUTLER BUILDING, ST. LOUIS, MO.

MAURAN, RUSSELL AND GARDEN, Architects.

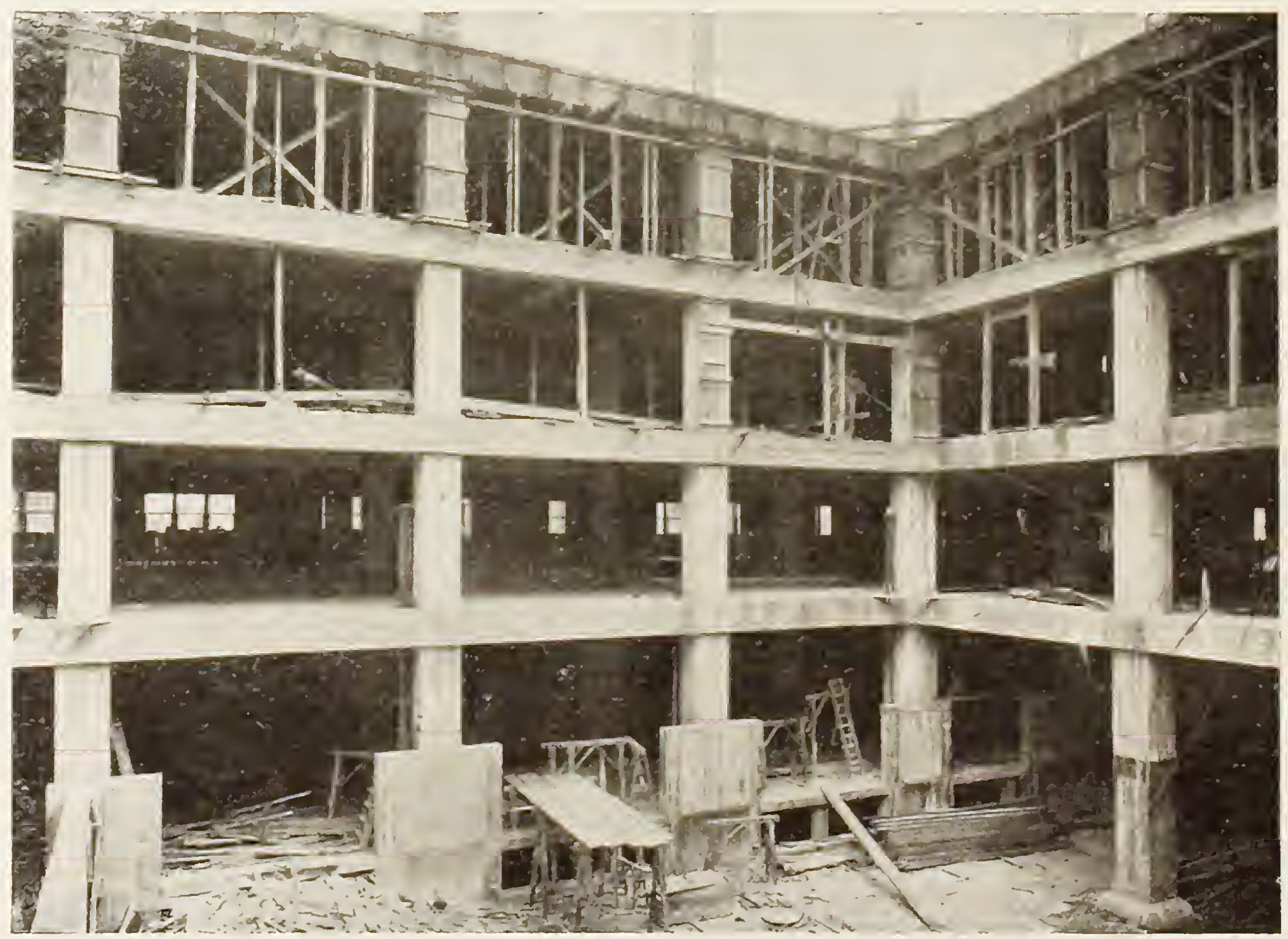
JAMES BLACK MAS. AND CONTR. CO., Contractors.

EXPANDED METAL AND CORRUGATED BAR CO., Engineers.

The upper view gives a general idea of the construction methods; the lower one shows the loading and light court in the center of the building.

CONSTRUCTION VIEWS OF THE BUTLER BUILDING.

This building is of all concrete construction with heavy brick exterior walls. The over all dimensions are 284'x324'; eight stories. Column centers 18' and 22' by 20', ribbed floor construction; 4" slab, ribs 10' apart, designed for load of 150 lbs. per square foot.



WAREHOUSE FOR THE BELKNAP HARDWARE AND MANUFACTURING CO., LOUISVILLE, KY.

McDonald and Dodd, Architects. O. G. Joseph, Engineer. The Oliver Co., Contractors.

All concrete construction; brick curtain walls. Over all dimensions, 200'x175', nine stories and basement. Floor loads 400 lbs., 350 lbs., and 300 lbs. per square foot.

BELKNAP BUILDING.

Detail showing cantilever construction for side walls.

WHOLESALE MERCHANTS' WAREHOUSE, NASHVILLE, TENN.

McDonald and Dodd, Designing Architects. W. H. Burk, Engineer. The Oliver Co., Contractors.

Interior View.

Detail View Showing Loading Platform and Awning.

DETAIL VIEWS
WHOLESALE MERCHANTS' WAREHOUSE.

All concrete construction, brick veneer walls; over all dimensions 140'x500'—4 stories, basement and sub-basement. Column centers, 12'x16' 7½"; floors, flat slab type designed for loads of 250 to 400 lbs. per square foot.

The upper view shows the special column reinforcement, the lower one the construction of a "combined" reinforced concrete footing.

WAREHOUSE FOR
ADVANCE THRESHER COMPANY,
KANSAS CITY, MO.

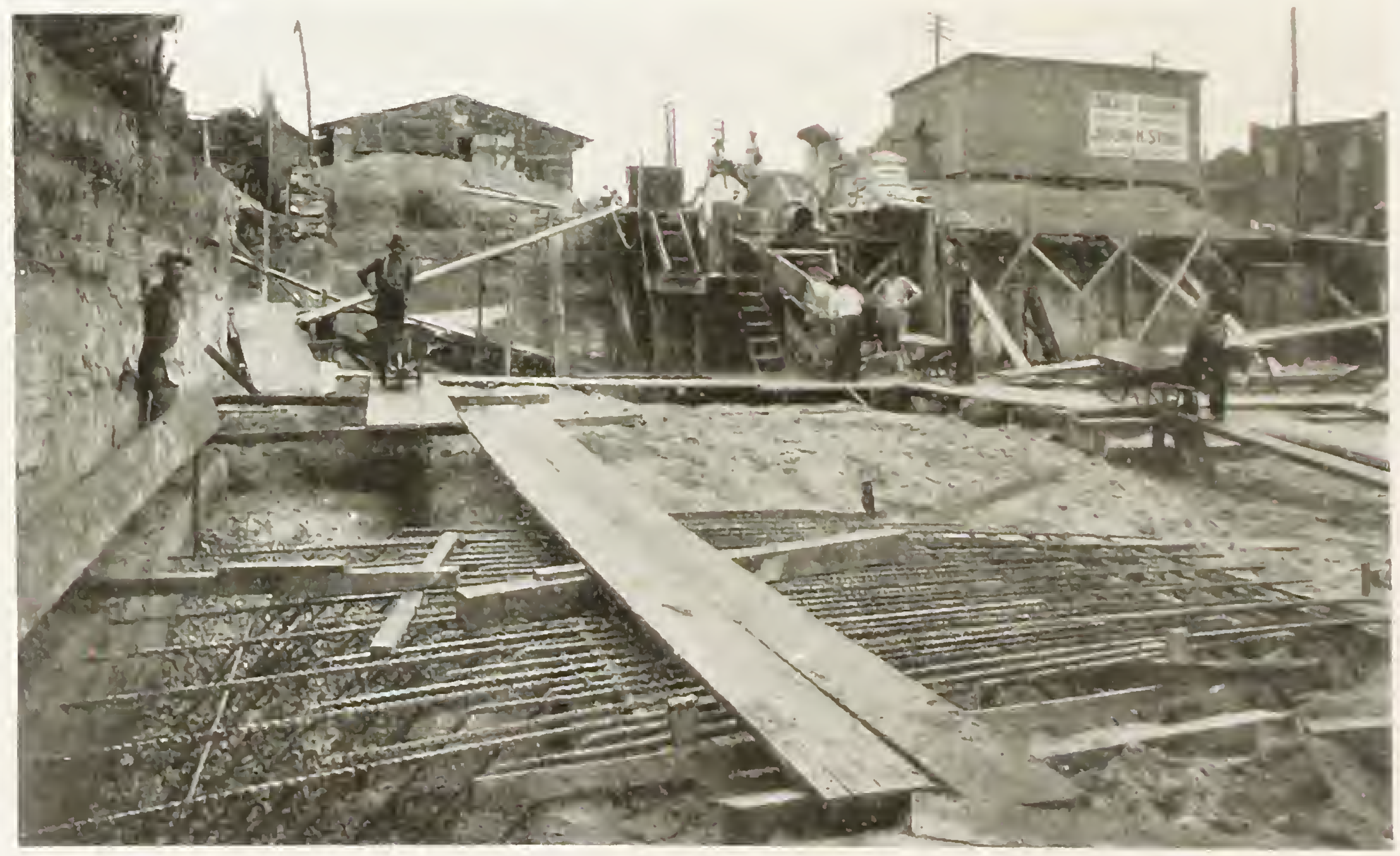
J. C. Llewellyn, Architect.

Jas. O. Hogg, Supervising Architect.

Condron and Sinks Co., Engrs. for Concrete Work.

Jos. H. Stone, Contractor.

All reinforced concrete construction. Over all dimensions 80'x100', four stories and basement.



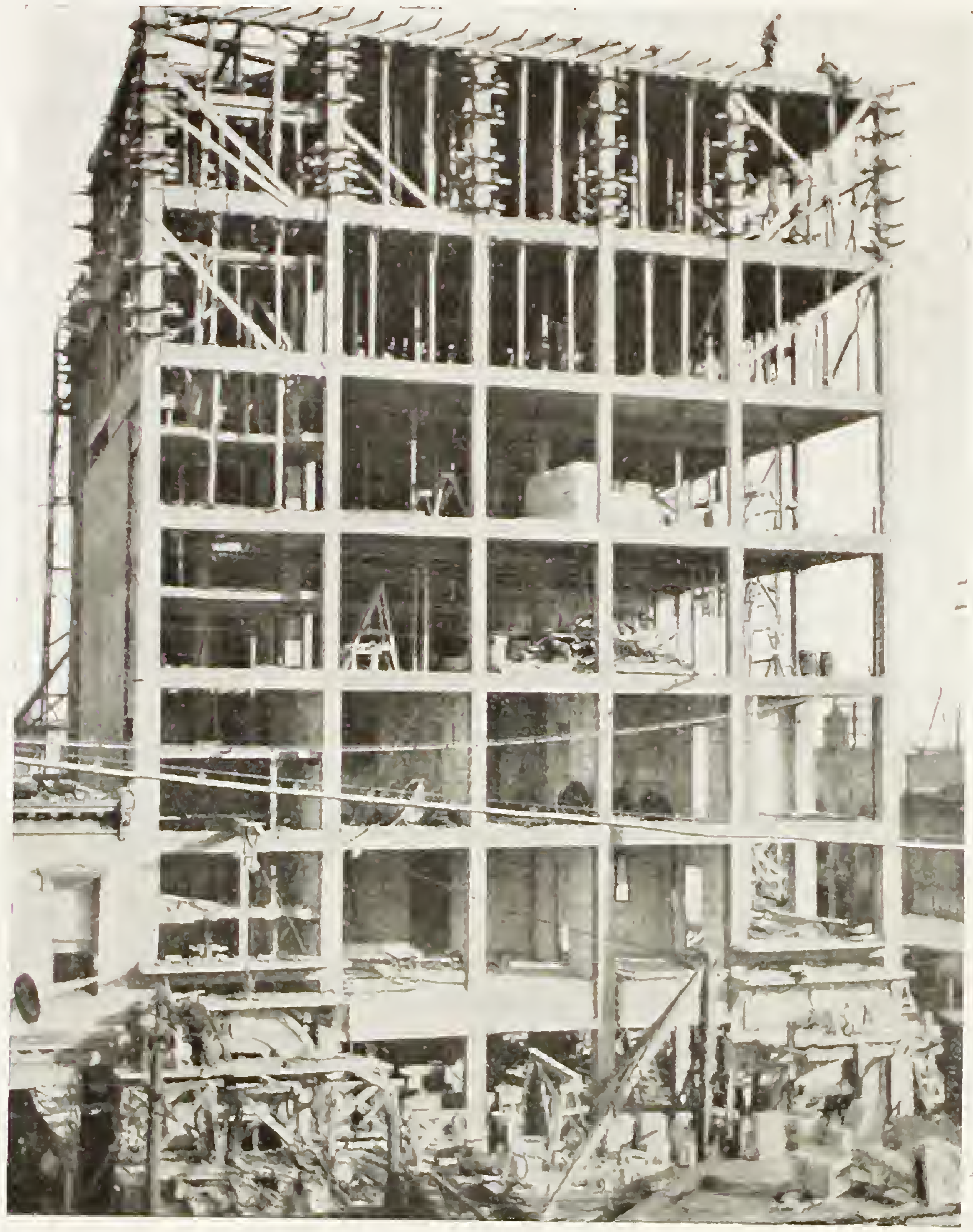
Views showing floor construction and test load on one panel. The test was carried out under the direction of the Building Department of Chicago. Floors were designed for a working load of 500 lbs. per square foot, and were tested to 1000 lbs. per square foot with a deflection of $^1/_{64}$ inch. Span 8′ 0″; slabs 6″ thick with a ¾″ wearing surface, total 6¾″.

HEATH AND MILLIGAN MFG. CO. BUILDING, CHICAGO.

MYRON H. CLARK, Architect.

ALBERT H. WOLF, Consulting Engineer.

CONDRON AND SINKS CO.,
Engineers for Reinforced Concrete.



MASONIC TEMPLE, RALEIGH, N. C.

CHAS. McMILLEN, Architect. W. H. BURK, Engineer.
CENTRAL CAROLINA CONSTRUCTION CO., Contractors.

BLOUNT COUNTY COURT HOUSE, MARYVILLE, TENN.

BAUMAN BROS., Architects.
W. H. BURK, Engineer.

PRITCHARD RICE MILLS, HOUSTON, TEX.

H. N. Jones, Architect and Builder.

Expanded Metal and Corrugated Bar Co., Engineers.

All reinforced concrete construction. Over all dimensions 70'x54' and 22'x54'.

IDEAL BUILDING, DENVER, COLO.

Fallis and Stein, Architects.

Whitney-Steen Co., Contractors.

All reinforced concrete construction. Over all dimensions 50'x125'. Eight stories and basement.

Finishing Roof.

COTTON WAREHOUSE, ATLANTIC COMPRESS CO., ATLANTA, GA.

W. H. Burk, Engineer.

The Oliver Co., Contractors.

All reinforced concrete construction, brick curtain walls. Over all dimensions 200'x506'.

Test Data: Floors, flat slab type; span, 15'-9"; safe load, 600 lbs. per sq. ft.; test load, 1,500 lbs per sq ft.; deflection $^{9}/_{64}$" at center of panel; permanent set, none.

Illustrations: Test load in place and under side of floor tested.

Remarks: Test satisfactory in all respects.

REINFORCED CONCRETE FLOORS,
FERMENTATION HOUSE,
WM. J. LEMP BREWING CO., ST. LOUIS.

GUY T. NORTON, Architect.

The over all dimensions of this building are 69'-0"x106'-0" and there are six stories. The floors are carried by steel columns and beams, the concrete slab having a span of 15'-9".

FACTORY BUILDING, COLGATE AND CO., JERSEY CITY, N. J.

WILLIAM P. FIELD, Engineer. THOMPSON-STARRETT CO., Contractors.

All concrete construction, reinforced concrete exterior walls. Over all dimensions, 84'x98'; column centers, 16'x21'. This is an addition to existing building, as shown in illustration.

The interior view shows the heavy electrical machinery supported by the concrete floor.

POWER HOUSE, WEST SIDE POWER, HEAT AND LIGHT CO., ST. PAUL, MINN.

OSCAR CLAUSSEN, Engineer.

W. H. BRINK, Superintendent.

Brick exterior walls, reinforced concrete floors, foundation and tunnel. Over all dimensions, 90'x 115'; column centers, 15'x17'. Floors designed for safe load of 300 lbs. per square foot.

T. W. CORDER BUILDING, OAKLAND, CALIFORNIA.

Oliver and Foulkes, Architects. J. B. Leonard, Engineer. Lindgren-Hicks Co., Contractors.

All concrete construction, with brick-faced reinforced concrete walls. Over all dimensions 60'x100', six stories and basement.

T. W. CORDER BUILDING—INTERIOR VIEW.

These views show the car barns at 77th street and Vincennes avenue; the area of the roof being about 5 acres. The same construction was used in the Cottage Grove Avenue car barns which cover practically the same area.

CAR BARN, CHICAGO CITY RAILWAY COMPANY.

H. B. Fleming, Chief Engineer.

Condron and Sinks Co., Designing Engineers.

Reinforced concrete slab, supported on fire-proofed steel trusses. Span of roof slab between trusses, 16 feet.

The upper illustration gives a general view of the three buildings during construction, the lower one shows, in more detail, the construction of building "B."

BUILDINGS, BOSTON WOVEN HOSE AND RUBBER CO., EAST CAMBRIDGE, MASS.

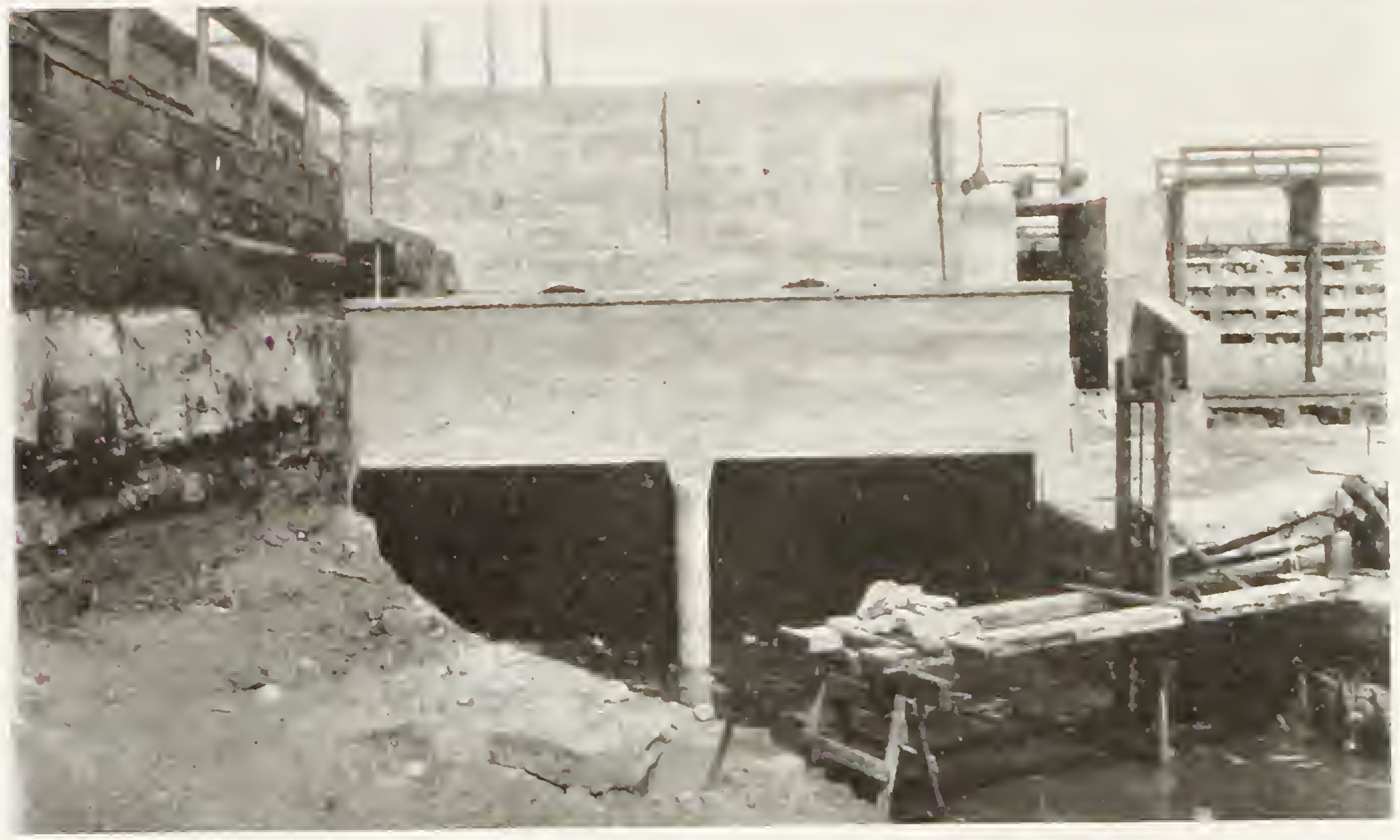
JOHN O. DEWOLFF AND CO., Architects and Engineers.

BENJAMIN FOX, Contractor.

SANFORD E. THOMPSON, Consulting Engineer.

EDW. A. TUCKER, Engineer for Concrete Construction.

There are three buildings. All concrete construction, as follows: Hose Building, 59'-0x321'-8"; Building A, 43'-0"x155'-1"; Building B, 55'-0"x 331'-2½". All four stories high. Floors were designed for safe loads varying from 150 lbs. to 300 lbs. per square foot.



HYDRO ELECTRIC POWER HOUSE, WISCONSIN POWER COMPANY, MENOMONIE, WIS.

EDW. P. BURCH, Engineer.

All concrete construction. Over all dimensions 30'x84'.

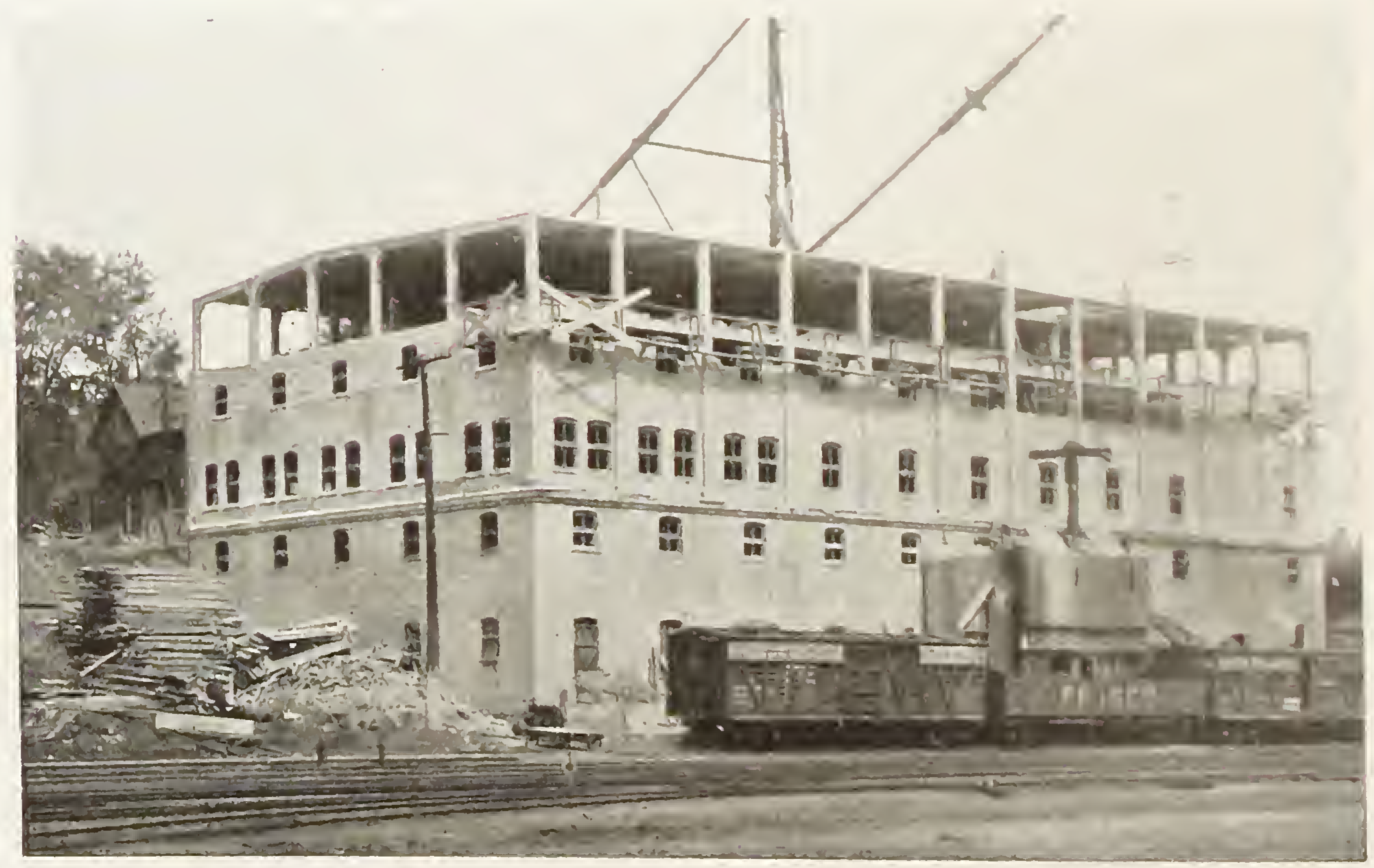
TRANSFER BUILDING, C., R. I. & P. RY. COMPANY, CEDAR RAPIDS, IOWA.

A. T. HAWK, Architect.

J. B. BERRY, Chief Engineer.

BARTLETT AND KLING, Contractors.

All concrete construction; brick curtain walls. Over all dimensions 74'x139'; five stories. Floors designed for loads of 200 and 400 lbs. per square foot.



JOHN NOBLE BUILDING,
PHOENIX, ARIZ.

HARRISON ALBRIGHT, Architect.

CARL LEONARDT, Contractor.

All reinforced concrete construction.
Over all dimensions 137′7″x149′10″.

HATELY COLD
STORAGE PLANT,
CHICAGO.

HUEHL AND SCHMIDT,
Architects and Engineers.

R. S. BLOME CO., Contractors.

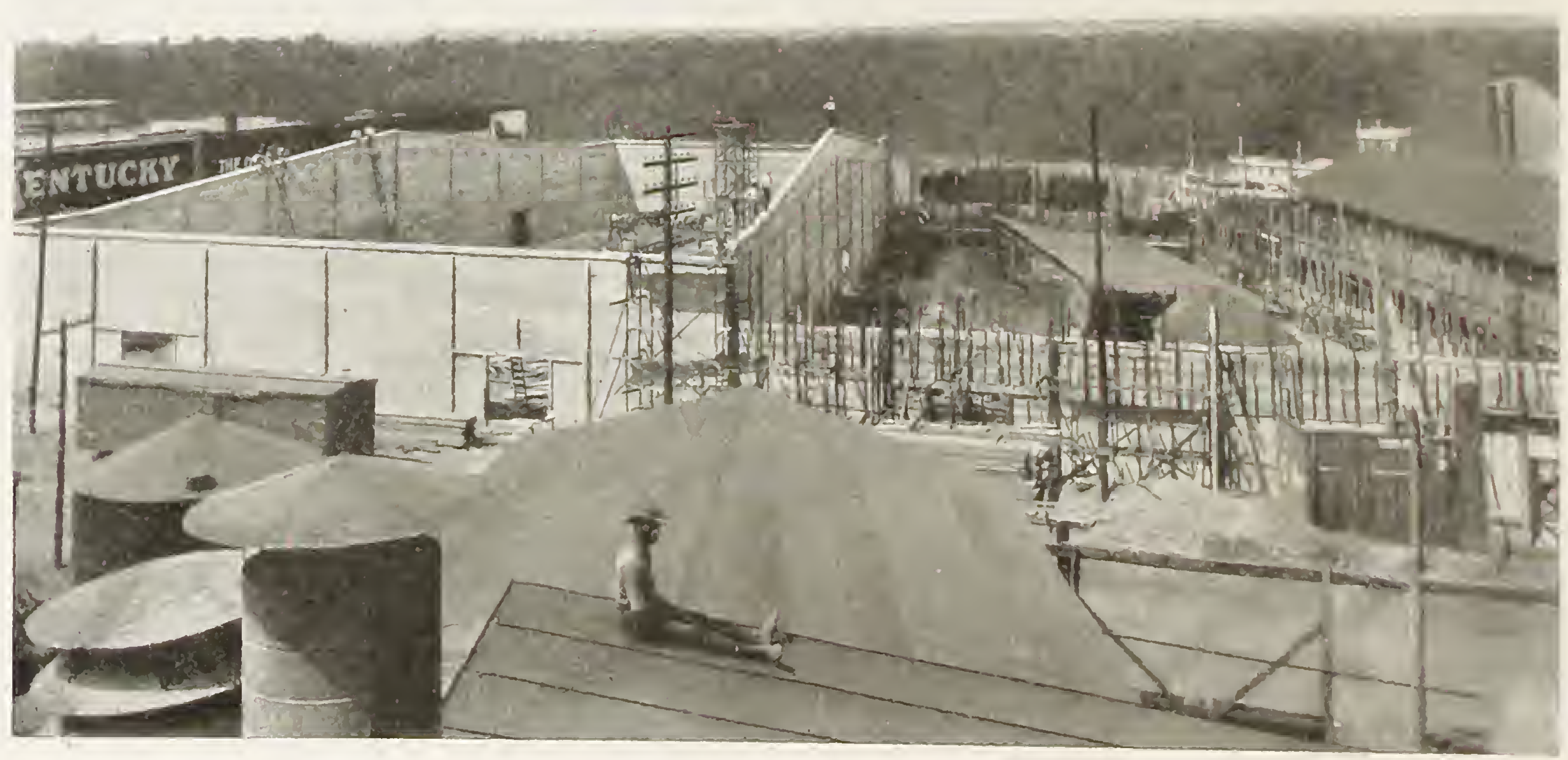
All reinforced concrete construction.

COLD STORAGE PLANT,
CRISTOBAL, CANAL ZONE

Isthmian Canal Commission.

F. B. Maltby, Prin. Asst. Engineer.

The refrigerating plant and cold storage building are constructed entirely of reinforced concrete.



WAREHOUSE FOR
P. D. WILLIAMS COMPANY,
VICKSBURG, MISS.

W. H. Burk, Eng. and Contr.

All reinforced concrete construction. Over all dimensions 230'x250'.

WALDORF HOTEL, ALDWYCH, LONDON.

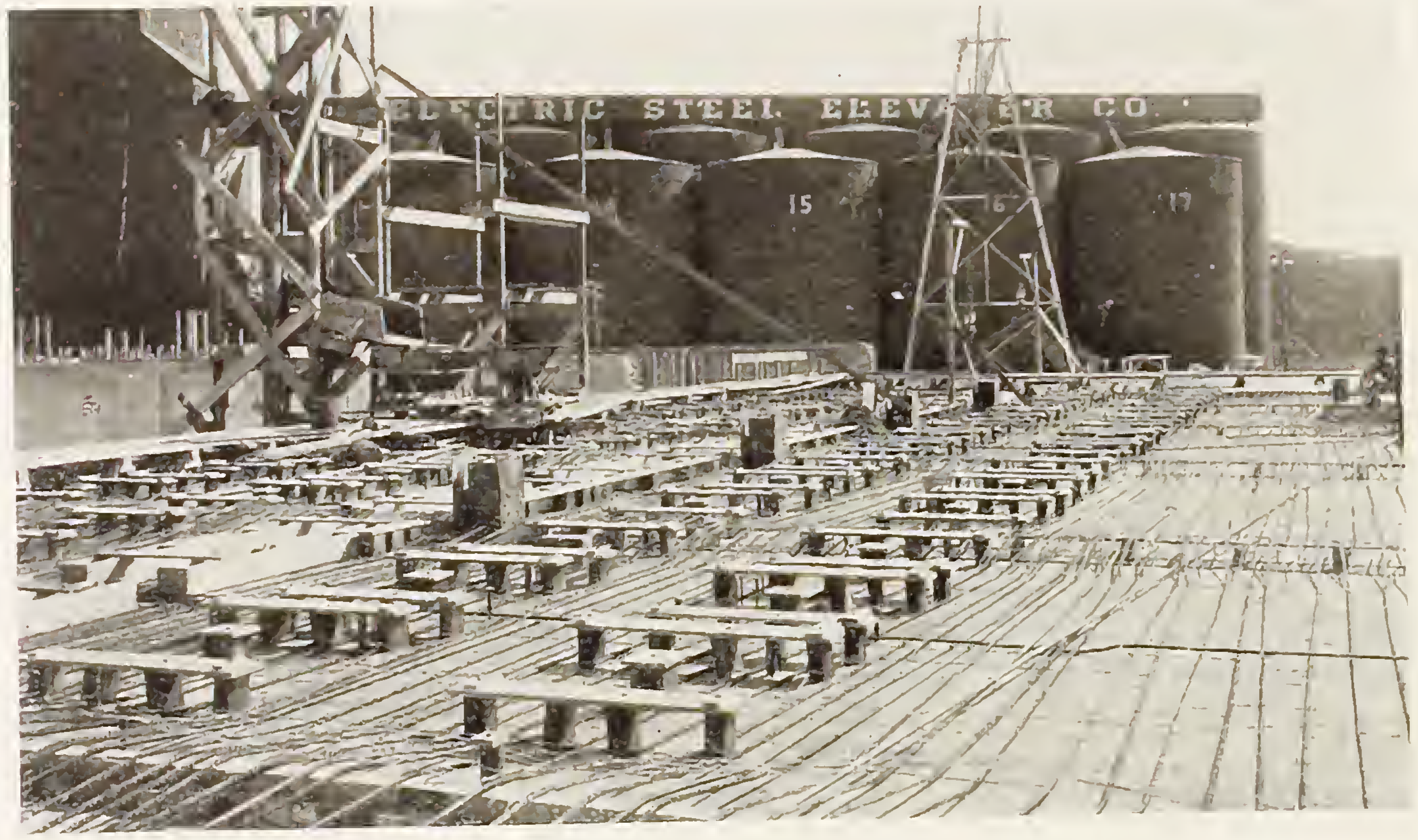
A. MARSHALL MACKENZIE AND SON, Architects. WARING-WHITE BUILDING CO., Ltd., Gen. Con. WATSON BROS., Contractors for Fireproofing.

Steel frame construction, reinforced concrete floors, roof and domes.

JOHN D. SPRECKEL'S "UNION BUILDING," SAN DIEGO, CAL.

HARRISON ALBRIGHT, Architect. C. LEONARDT, Contractor.

All concrete construction, reinforced concrete exterior walls. Over all dimensions, 85'x105'; six stories; column centers, 17' 11"x21' 5".



Over all dimensions, 344'x80', six stories. Roof over engine room carried by reinforced concrete beams of 60' span. Floors designed for live loads of 100 to 500 lbs. per square foot.

FLOUR MILL,
RUSSELL MILLER MILLING COMPANY,
MINNEAPOLIS, MINN.

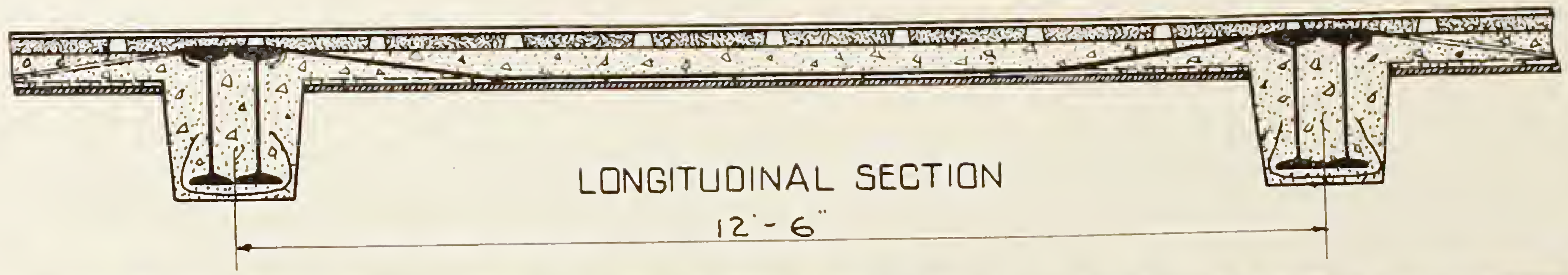
F. W. CAPPELEN AND E. H. LOE,
Architects and Engineers.

N. H. LEIGHTON, Contractor.

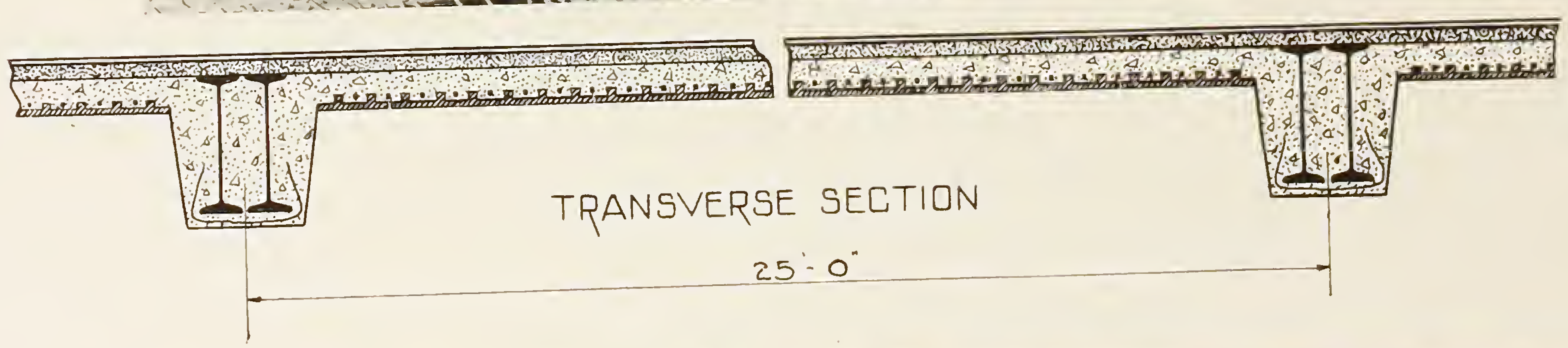
INTERSTATE HOTEL, BRISTOL, TENN.

BARBER AND KLUTTZ, Architects. W. H. BURK, Engr. and Contr. for Reinforced Concrete.

Building carried on reinforced concrete piers extending 50′ below grade. Basement designed to resist 12′ head of water.



Interior view of Syndicate Trust Building, showing floor construction and detail drawings of same. Floors are our flat slab type, tile protected, and represent the highest form of fire-proof construction. The tile not only protects the concrete, but also furnishes a proper key for the plaster. The concrete was placed on the tile, which took the place of the decking, thus effecting considerable saving in lumber.



SYNDICATE TRUST BUILDING, ST. LOUIS.

H. F. Roach, Architect. Hill-O'Meara Construction Co., Contractors.

Steel frame construction, reinforced concrete and tile floors. Over all dimensions 140'x230'. Seventeen stories.

SHELDON BUILDING, SAN FRANCISCO.

BENJ. G. MCDOUGALL, Archt. J. B. LEONARD, Engr.
THE LINDGREN-HICKS CO., Contractors.

All reinforced concrete construction. Over all dimensions 91′ 8″x137′ 6″; 6″ reinforced concrete exterior walls.

CRANE BUILDING, SEATTLE, WASH.

SAUNDERS AND LAWTON, Architects. J. RYAN AND CO., Contractors.

GENERAL CONT. CO., Con. for Fireproofing.

Steel frame construction, reinforced concrete floors.

RESIDENCE FOR W. G. BORLAND,
MOUNT KISCO, N. Y.

DELANO AND ALDRICH, Architects.

NEW CENTURY CONTRACTING CO., Contractor.

Combination hollow tile and reinforced concrete construction.

WAREHOUSE, ATLANTA, GA.

V. H. KREIGSHABER, Architect, Engineer and Contractor.

All concrete construction. Over all dimensions, 57'x160', two stories. Floors designed for safe load of 250 lbs. per square foot.

U. S. GRANT HOTEL, SAN DIEGO, CALIFORNIA.

HARRISON ALBRIGHT, Architect. C. LEONARDT, Contractor.

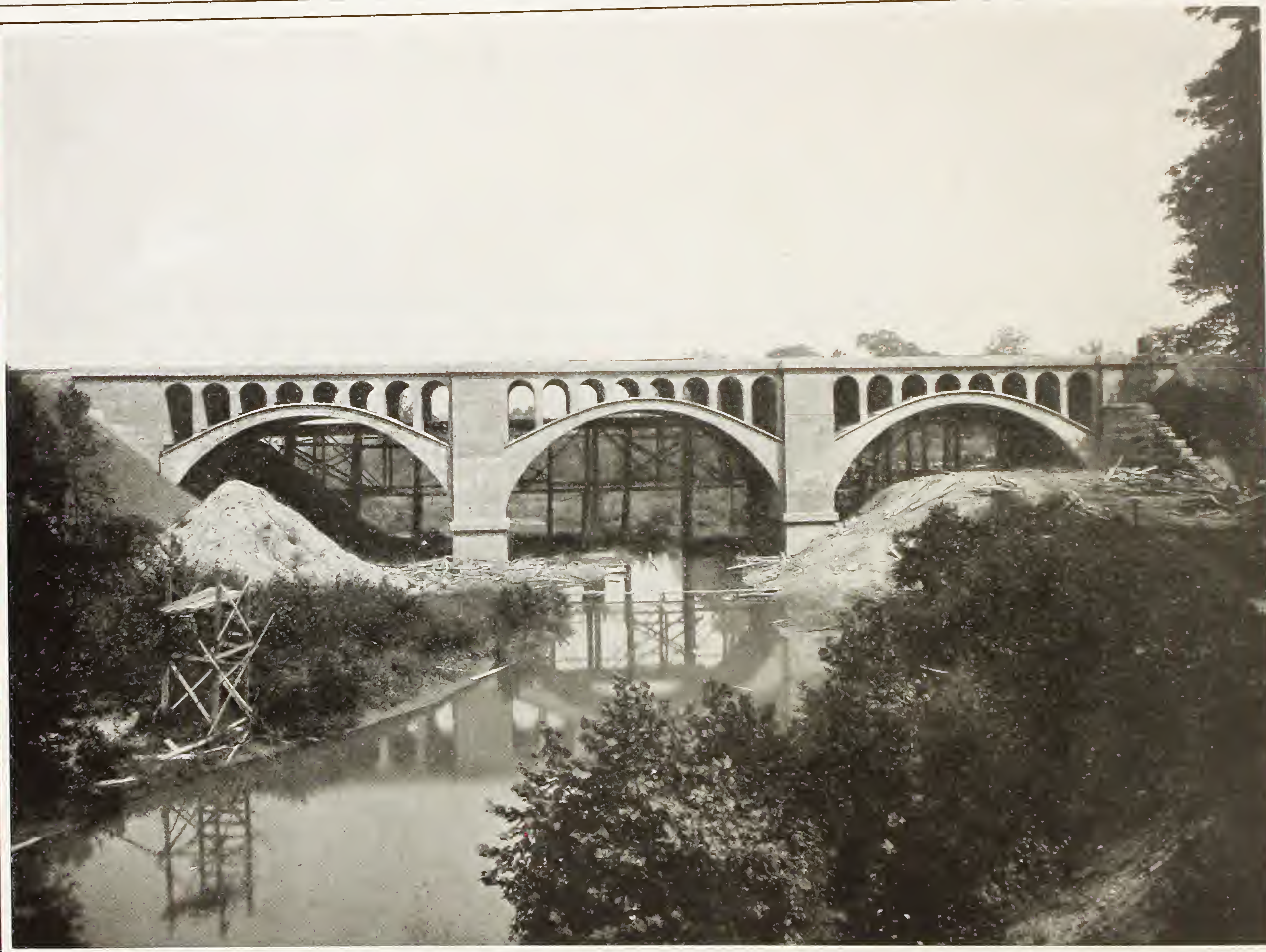
All concrete construction. Over all dimensions, 200'x200'; seven and nine stories. Ballroom on ninth floor carried by girders of 52 clear span.

Railroad Structures.

IN no class of reinforced concrete construction does the question of vibration and shocks and consequent apprehension as to the destruction of the adhesion between the concrete and steel enter so largely as in railroad work. It is not surprising, then, that the railway engineers were among the first to recognize the many advantages of the Corrugated Bar, and that is now considered the standard of excellence, which other forms of bar reinforcement vainly strive to approach.

It is often necessary, on account of the heavy concentrated loads met with in railroad practice, to develop the full stress in the reinforcement in a short length of bar, and we wish to call the attention of railway engineers to the superior mechanical bond of the Corrugated Bar, which makes it specially fitted for this work. The preceding sentence applies not only to the main reinforcing bars, but with equal force to shear members, stirrups, etc., and especially so as the length of these secondary members is restricted in most cases by the depth of the beam.

The following illustrations are typical and show the adaptability of Corrugated Bar reinforced concrete construction to all classes of railway work. We desire especially to call attention to the growing popularity of reinforced concrete trestle work, and short span, flat slab, or girder designs for permanent way construction.



DOUBLE TRACK ARCH BRIDGE BETWEEN TERRE HAUTE AND INDIANAPOLIS, BIG FOUR RY.

W. M. Duane, Chief Engineer. Savage Construction Co., Contractors.

BRIDGE OVER CLARK AVENUE, CLEVELAND, OHIO, BIG FOUR RY.

W. M. DUANE, Chief Engineer. Six tracks; span, 88′; skew, 45°. FATH AND SONS CONSTR. CO., Contractors.

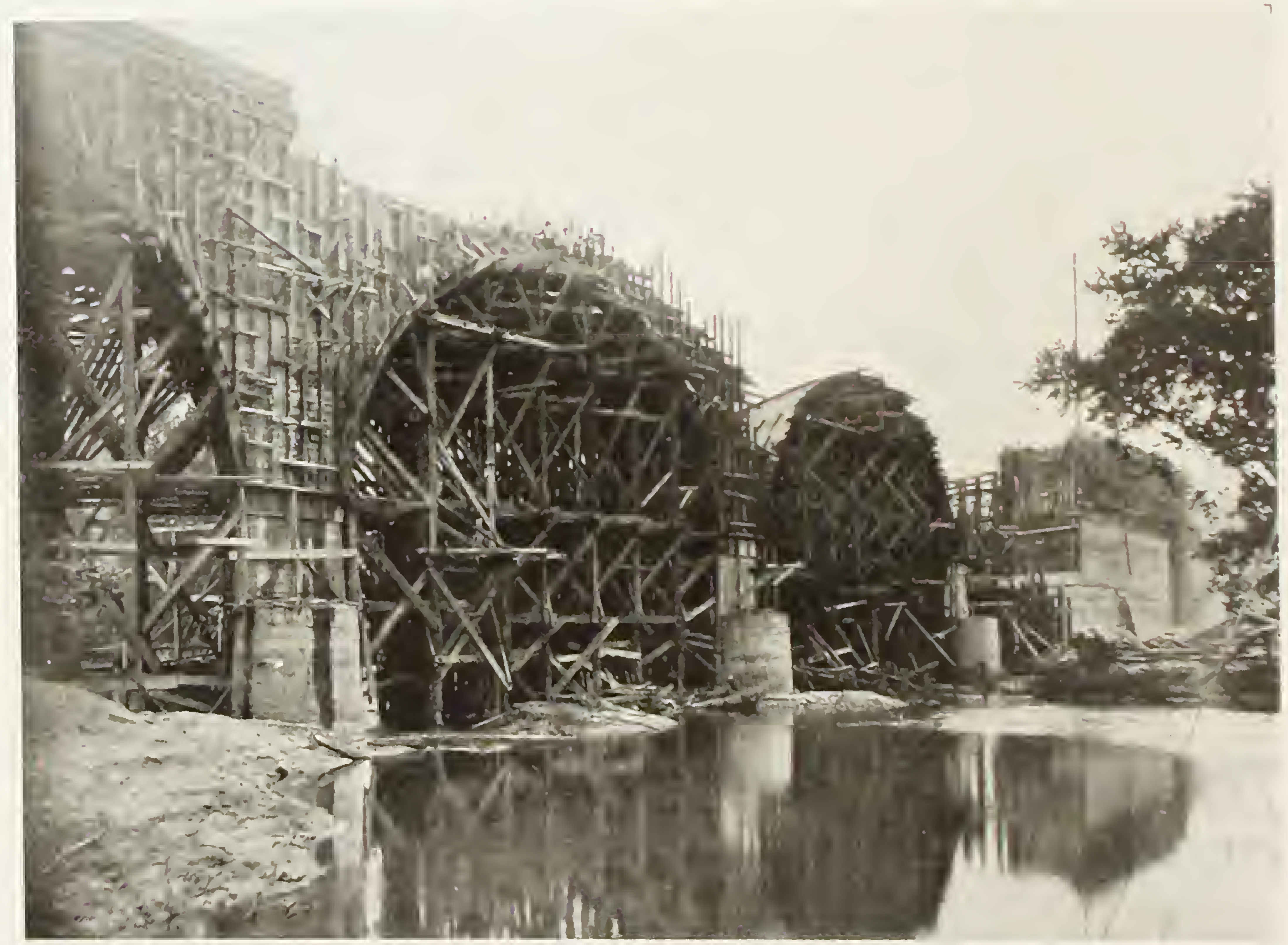
VIEWS DURING CONSTRUCTION.

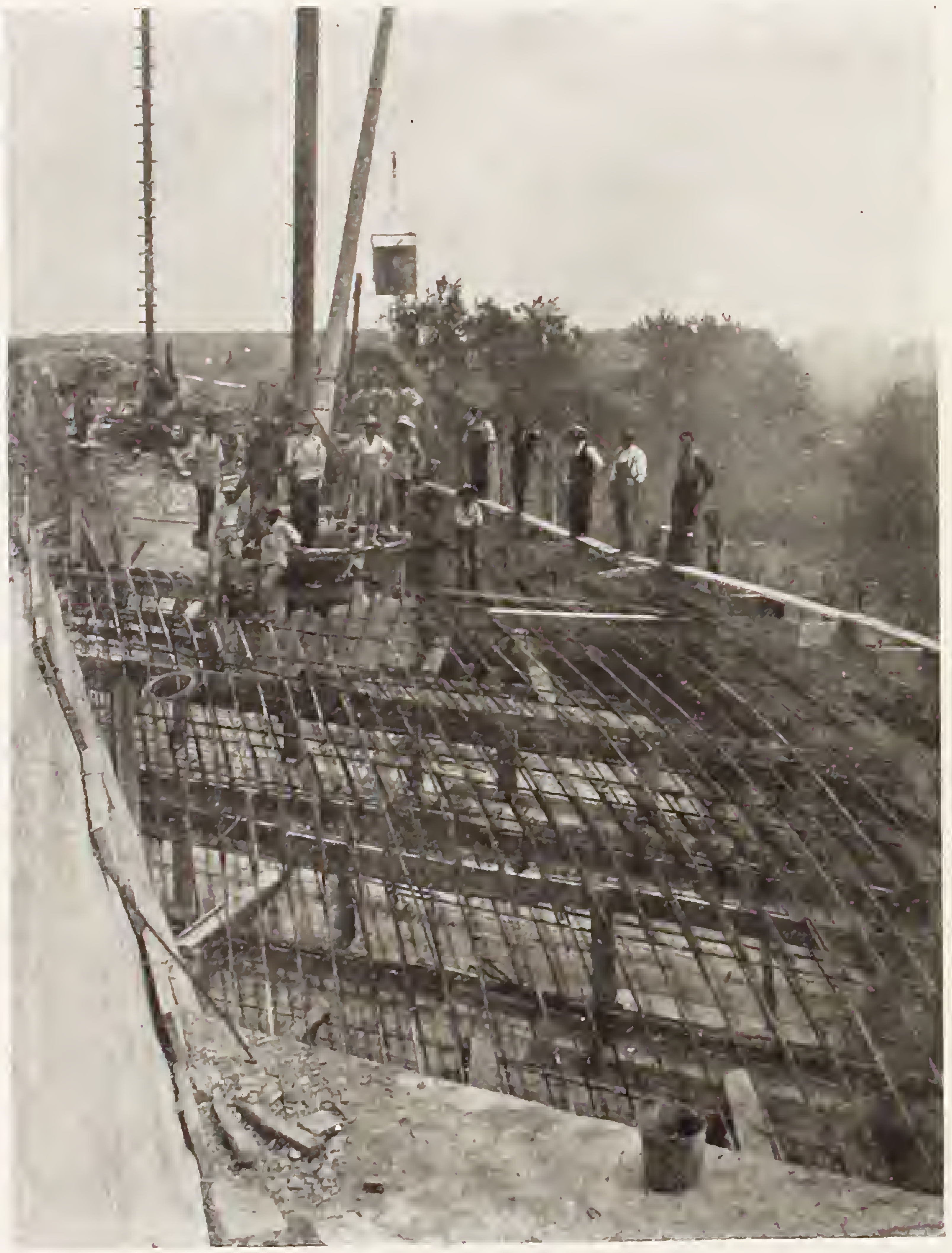
SANGAMON RIVER BRIDGE, WABASH RAILROAD, NEAR DECATUR, ILL.

A. O. CUNNINGHAM, Chief Engineer.

WM. P. CARMICHAEL CO., Contractors.

Double track bridge; four arches, 45° skew. Piers 100′ c. to c. along axis of bridge.





View showing method of handling concrete; arch reinforcement in place.

SANGAMON RIVER BRIDGE.

View showing hollow abutment, the side walls of which are 70′ high, and connected by cross walls or diaphragms.

Three-track bridge. Three arches, each 55′ clear span. Piers six feet wide at springing line.

REINFORCED CONCRETE
ARCH BRIDGE OVER EAGLE CREEK,
VANDALIA R. R. CO.

F. T. Hatch, Chief Engineer.

R. K. Rochester, Prin. Asst. Engineer.

J. E. Starbuck, Designiug Engineer.

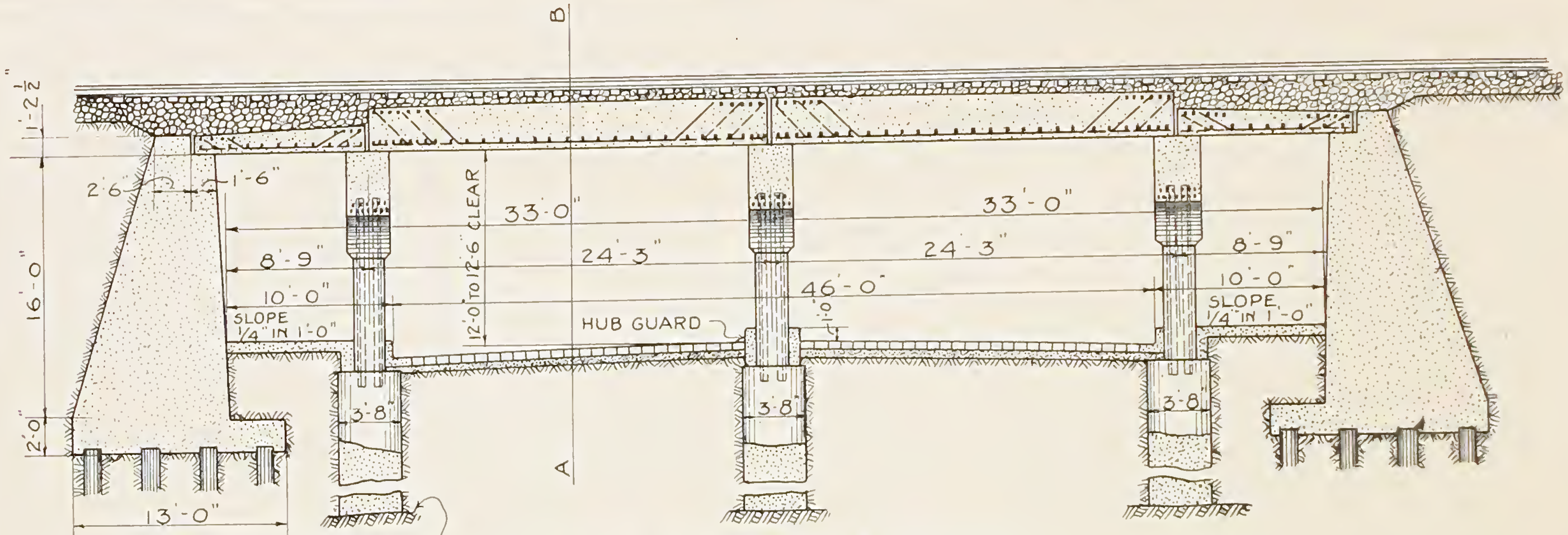
Moore Mansfield Constr. Co., Contractors.

FLAT CREEK ARCH, KNOXVILLE DIVISION, SOUTHERN RAILWAY.

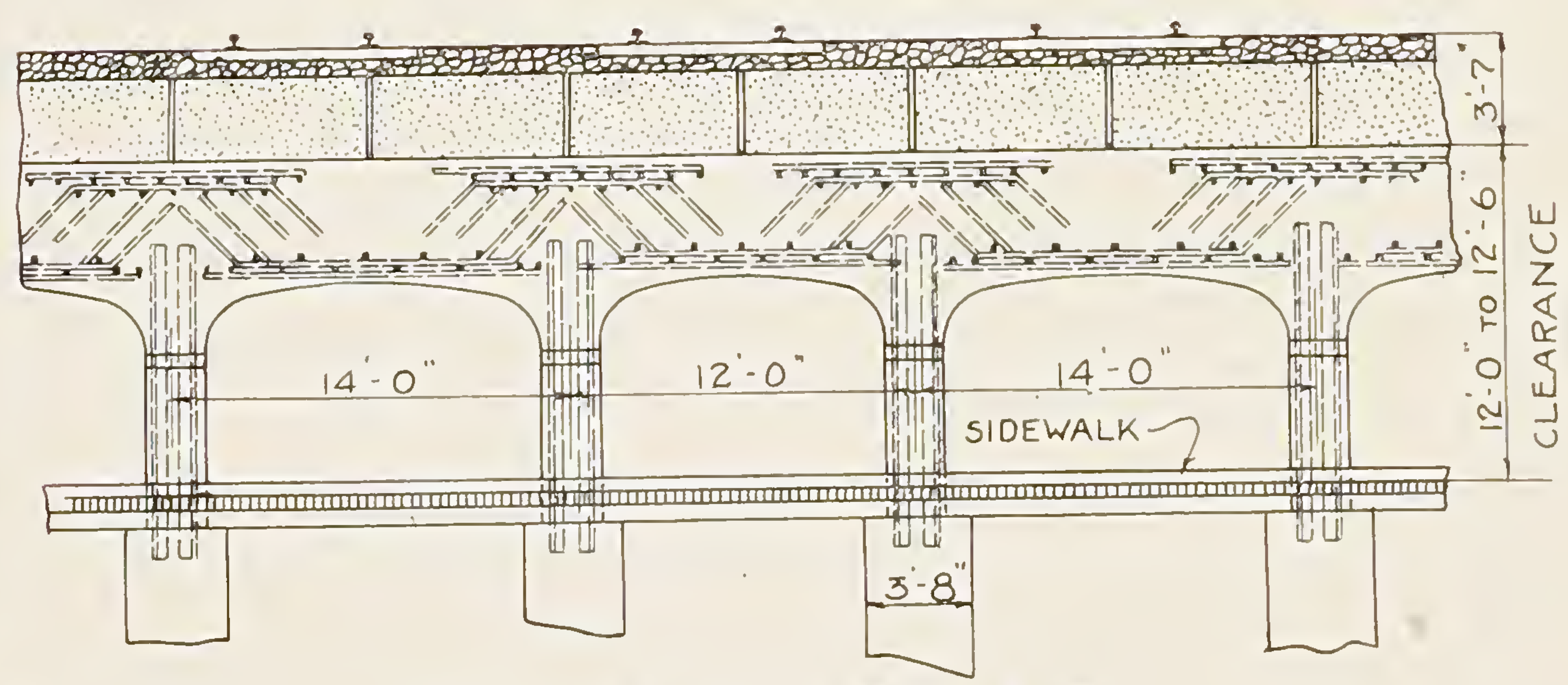
W. H. WELLS, Engineer Construction.
W. B. CRENSHAW, Principal Assistant Engineer.

MONDAY CONSTRUCTION CO., Contractors.
H. P. MEHLER, Engineer.

Double track; two 50′ semi-circular arches.



CROSS SECTION OF SUBWAY



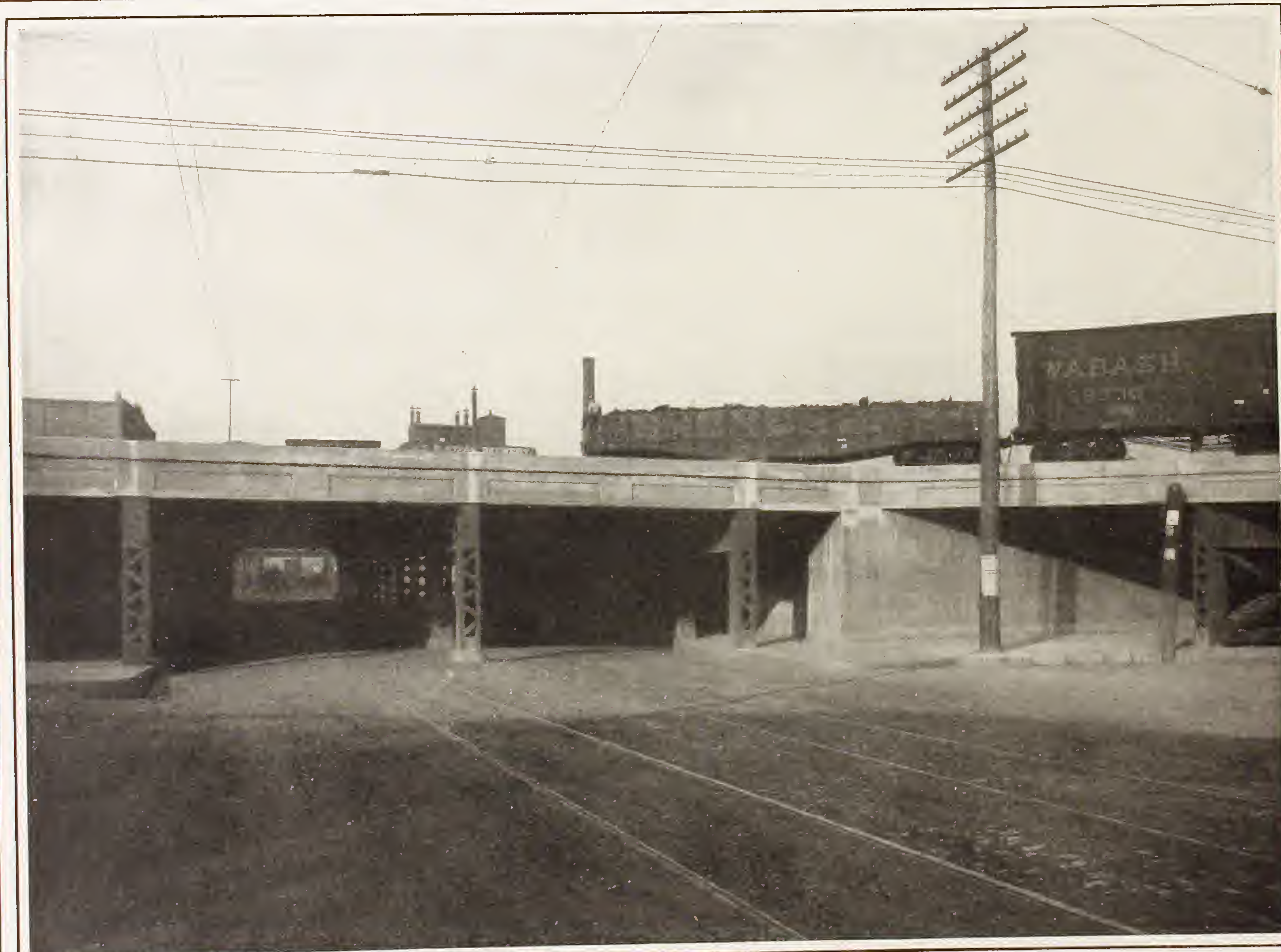
SECTION ON LINE A-B

C., B. & Q. RY. TRACK ELEVATION,
CANAL SREET TO BLUE ISLAND AVENUE.
TYPICAL SECTIONS AT SUBWAYS.

T. E. Calvert, Chief Engineer.

C. H. Cartlidge, Bridge Engineer.

Reinforced concrete slabs, carried by concrete bents; the slabs are made elsewhere and placed when sufficiently aged. The photograph on opposite page shows similar structure, steel bents however being used; concrete bents are used in the later work. See pages 62 and 63 showing similar work on the I. C. Ry.



TRACK ELEVATION WORK, C., B. AND Q. RY., ASHLAND AVENUE, CHICAGO.

SLABS IN CURING YARD.

For drawing showing similar construction on the C., B. & Q., see page 60.

TRACK ELEVATION WORK,
ILLINOIS CENTRAL RAILWAY CO.,
CHICAGO.

Showing forms with bars in place, ready for concreting.

TRACK ELEVATION WORK, ILLINOIS CENTRAL RAILWAY CO., CHICAGO.

A. S. Baldwin, Chief Engineer. R. E. Gaut, Engineer Bridges.

Reinforced concrete bents ready to receive the slabs.

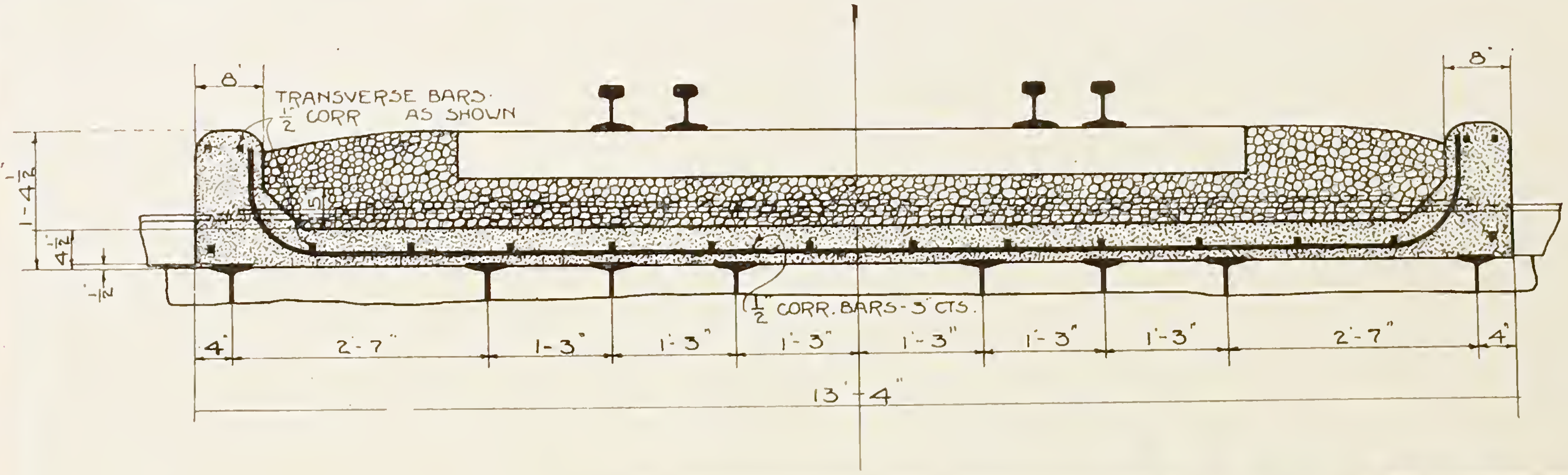
BRIDGE 62, BUFFALO DIVISION,
L. S. & M. S. RY.

Edw. A. Handy, Civil Engineer.

BRIDGE 243, BUFFALO DIVISION,
L. S. & M. S. RY.

S. Rockwell, Chief Engineer.

VIEWS SHOWING WIDENING OF BRIDGES ON THE BUFFALO DIVISION OF THE L. S. & M. S. RY.



TRANSVERSE SECTION THROUGH FLOOR.

SOLID REINFORCED CONCRETE FLOOR.

BRIDGE No. 13.78 OVER BRUSH CREEK, C., B. & Q. R. R.

W. L. BRECKENRIDGE, Chief Engineer.

C. H. CARTLIDGE, Bridge Engineer.

Data: Over all length, 795 ft.; extreme height, 32'-0"; face wall, 7¼" thick at top, 14¾" at bottom; butresses, 12" thick, 8'-0" on centers.

RETAINING WALL, PALOUSE, WASHINGTON, SPOKANE AND INLAND RAILWAY.

M. T. CHAMBERLAIN, Consulting Engineer.

GENERAL CONTRACTING CO., Contractors.

EIGHTH STREET BRIDGE,
KANSAS CITY.

OVERHEAD BRIDGE,
TENTH STREET,
KANSAS CITY.

REINFORCED CONCRETE ABUTMENTS
KANSAS CITY OUTER BELT
AND ELECTRIC R. R.

M. P. PARET, Chief Engr., K. C., M. & O. RY.

W. W. COLPITTS, Asst. Chief Engr.

No. 1.

No. 2.

No. 1—NORTH ABUTMENT, SYCAMORE CREEK VIADUCT.
SOUTHERN RAILWAY.

Russell and Oliver, General Contractors.

Miller Bros., Contractors for Concrete Construction.

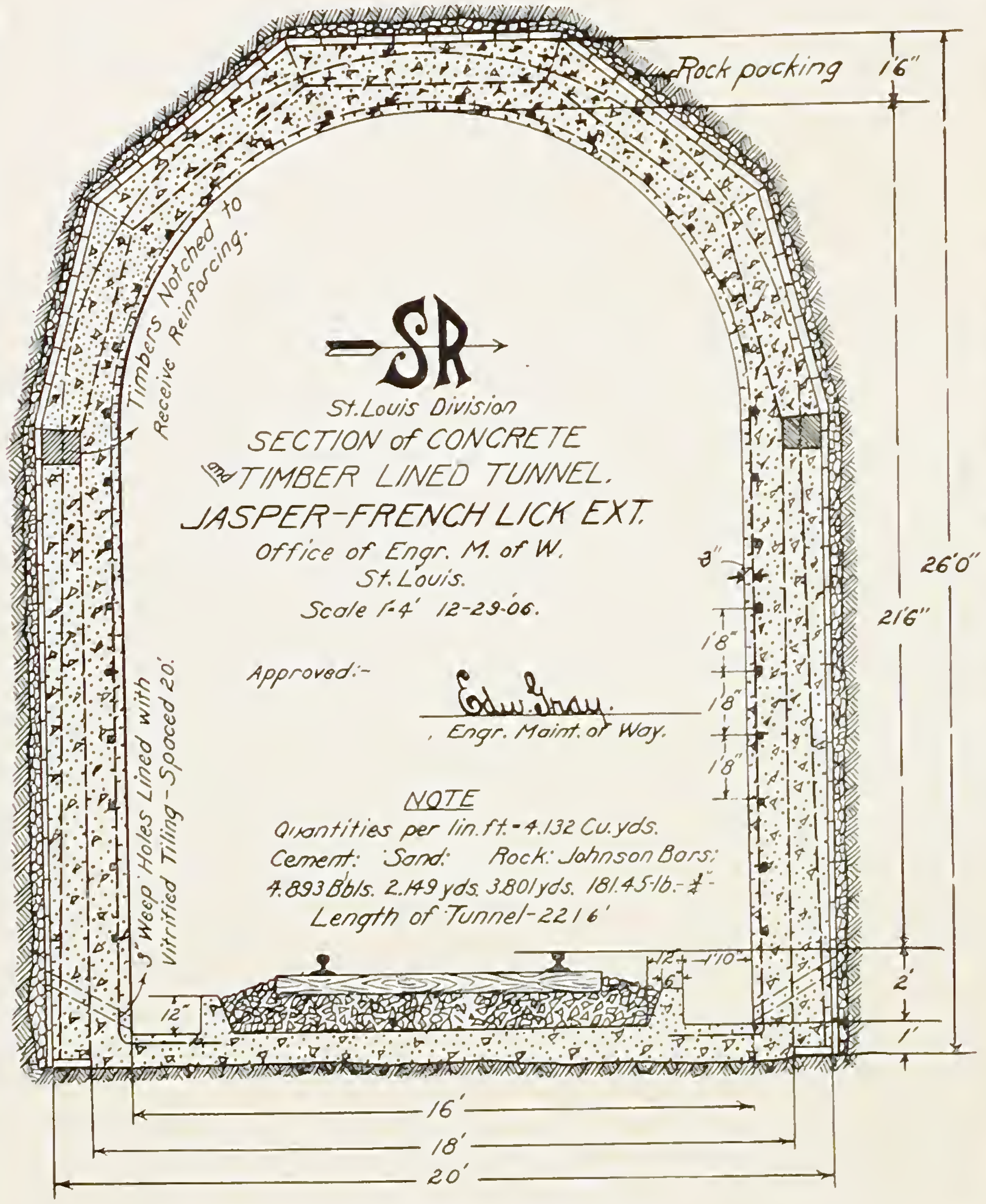
No. 2—END VIEW REINFORCED CONCRETE
RETAINING WALL,
TRACK ELEVATION WORK, C., B. & Q. RY., CHICAGO.

C. H. Cartlidge, Bridge Engineer.

BRIDGE 100-43 OVER SALT RIVER, C., B. & Q. R. R.

T. C. Calvert, Chief Engineer. C. H. Cartlidge, Bridge Engineer.

This bridge is supported by reinforced concrete piles, 22′ long, driven with a 3000-pound hammer, max. fall 24′. The spans are 14′ c. to c., and the average height is 10′; total length, 477′ 6″.



SECTION OF TUNNEL.

The tunnel is 2216 feet long. Note the unusual section of concrete bottom.

VIEW SHOWING PORTAL.

BURTON GAP TUNNEL, SOUTHERN RAILWAY, ST. LOUIS-LOUISVILLE LINES.

Edw. Gray, Engineer M. of W., St. Louis-Louisville Lines, In Charge of Construction.

McArthur Bros., General Contractors.

Cullen-Friestedt Company, Contractors for Concrete Lining.

COMBINATION ROADWAY AND WATERWAY ARCH.

The roadway is carried by a 13″ reinforced slab which forms the roof of the waterway.

TYPICAL REINFORCED CONCRETE STRUCTURES ON THE JASPER-FRENCH LICK LINE OF THE SOUTHERN RAILWAY.

W. H. WELLS, Engineer of Construction.

EDW. GRAY, Engineer M. of W. in Charge of Design and Construction.

The lower illustration shows reinforced concrete bridge No. 61.7.

First C., B. & Q. Culvert.
Showing general view of entrance.

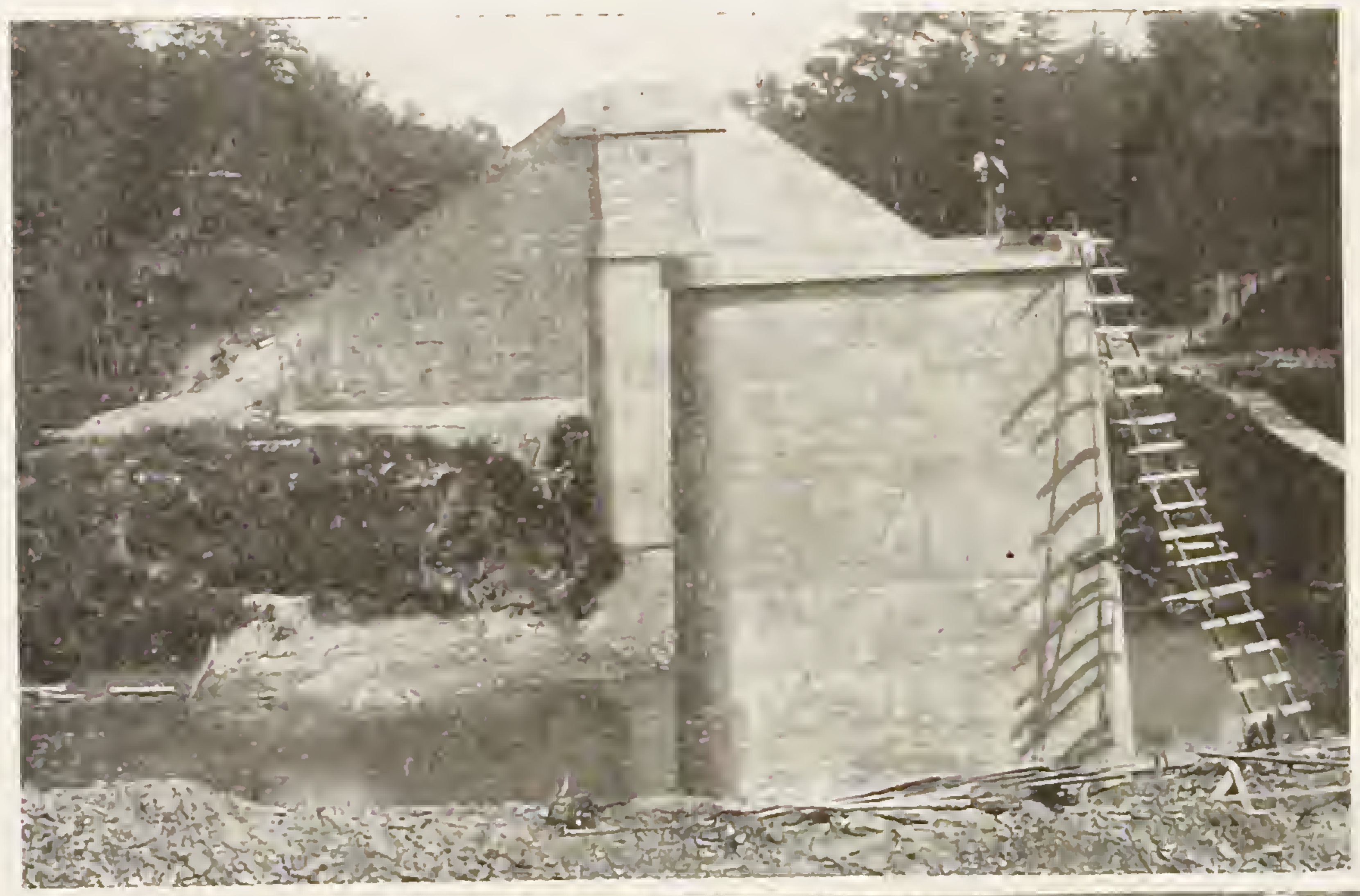
Second C., B. & Q. Culvert.
Showing general view of outlet end.

REINFORCED CONCRETE CULVERTS. HUNTLEY IRRIGATION PROJECT, MONTANA.

UNITED STATES RECLAMATION SERVICE.

Second C., B. & Q. Culvert.

Showing steel in place.



REINFORCED CONCRETE ABUTMENT
CAHABA RIVER CROSSING,
A., B. & A. R. R.

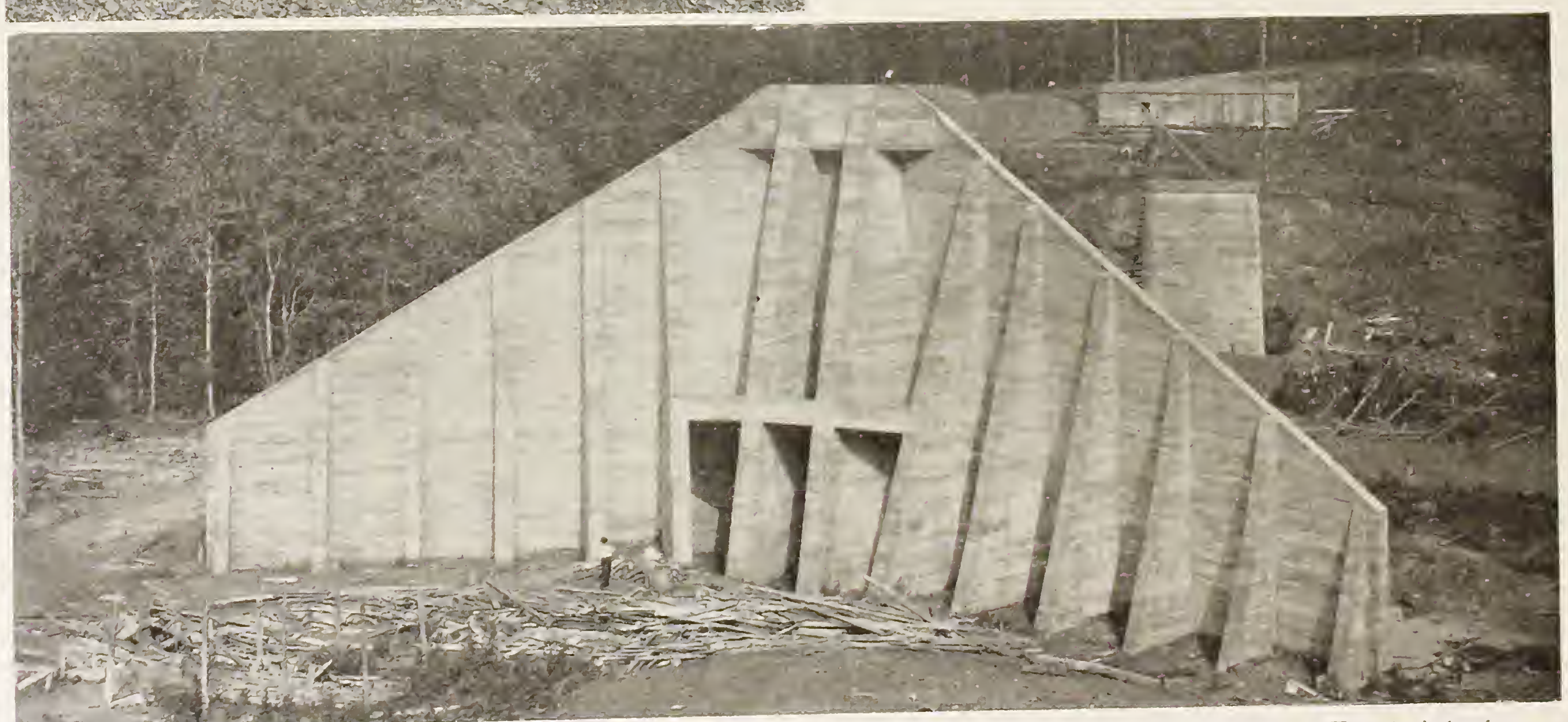
ATLANTIC AND BIRMINGHAM CONST. CO.,

Alex. Bonnyman, Chief Engineer.

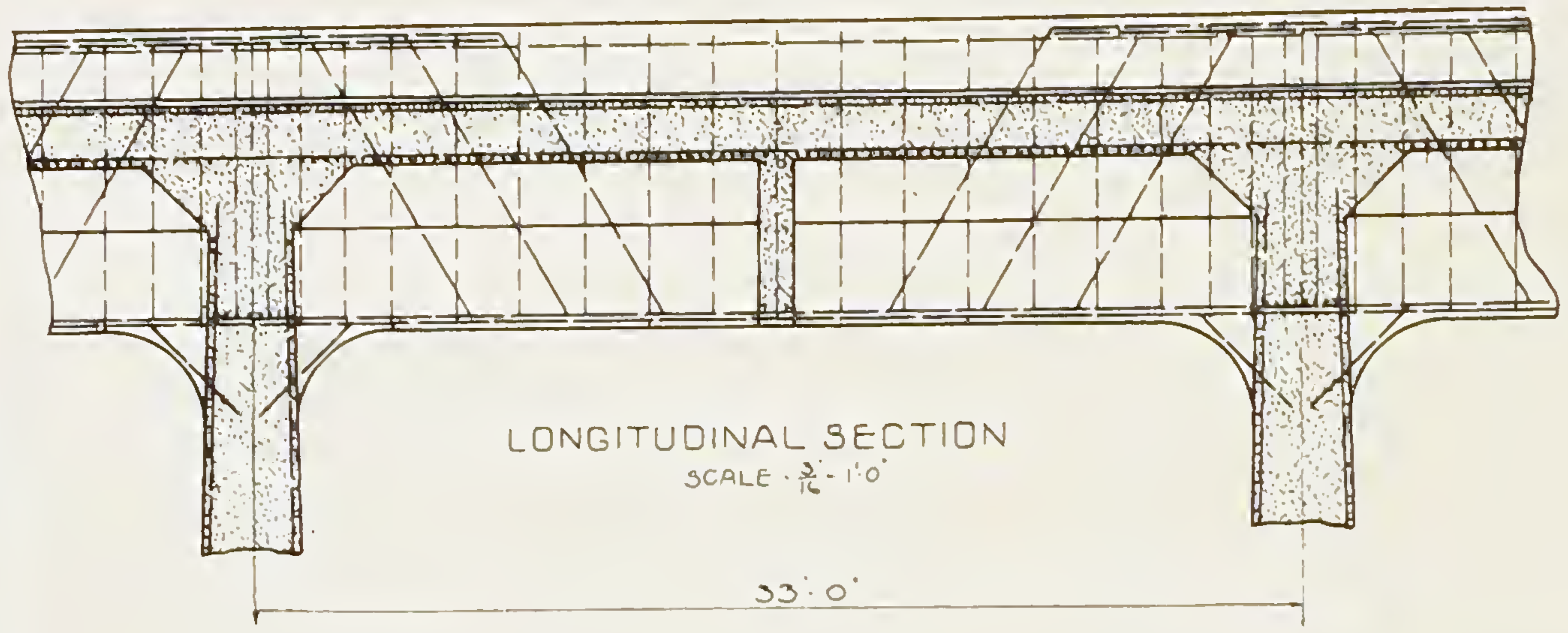
S. L. Morrow, Office Engineer.

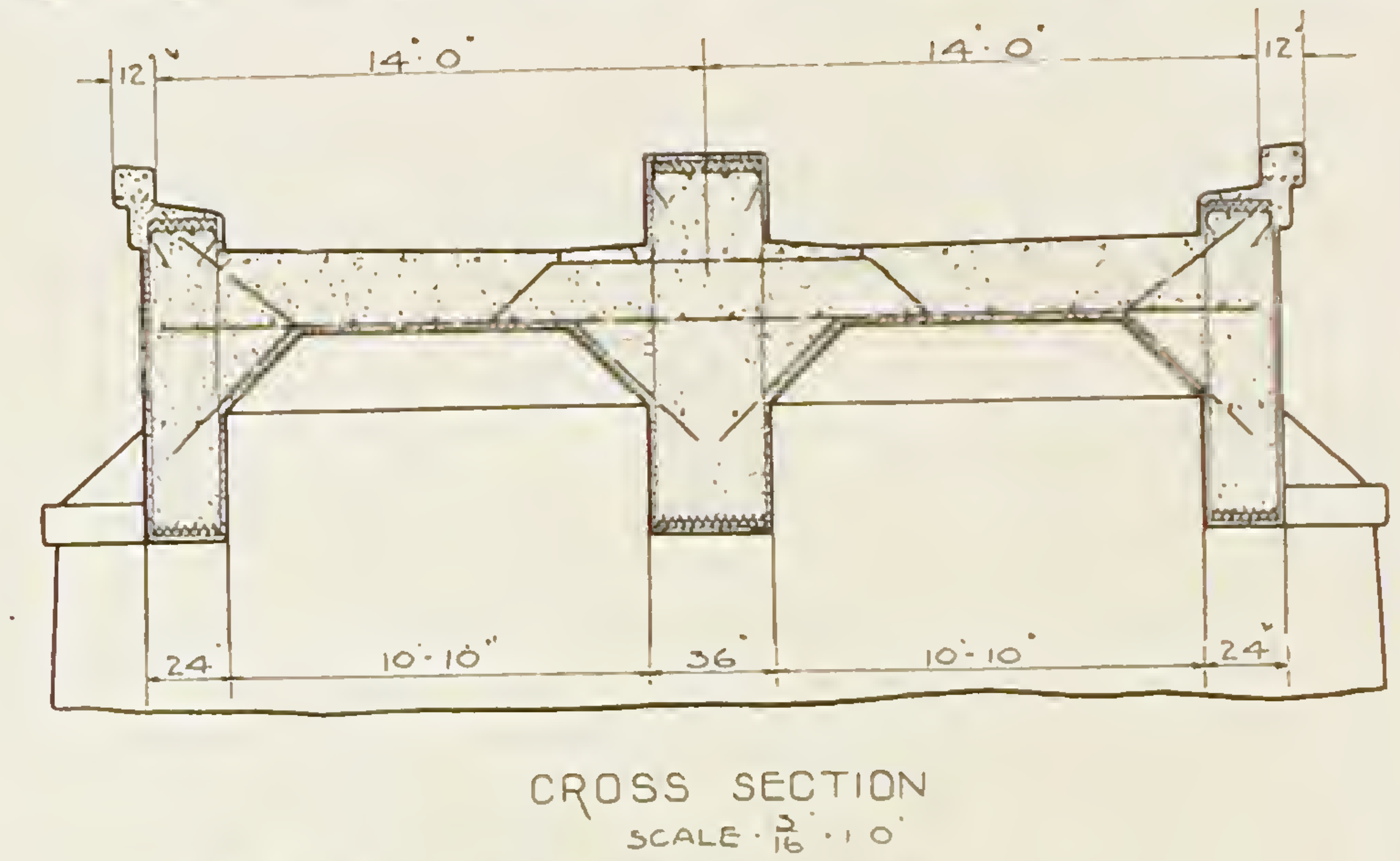
M. O. Bellingrodt, Designing Engineer.

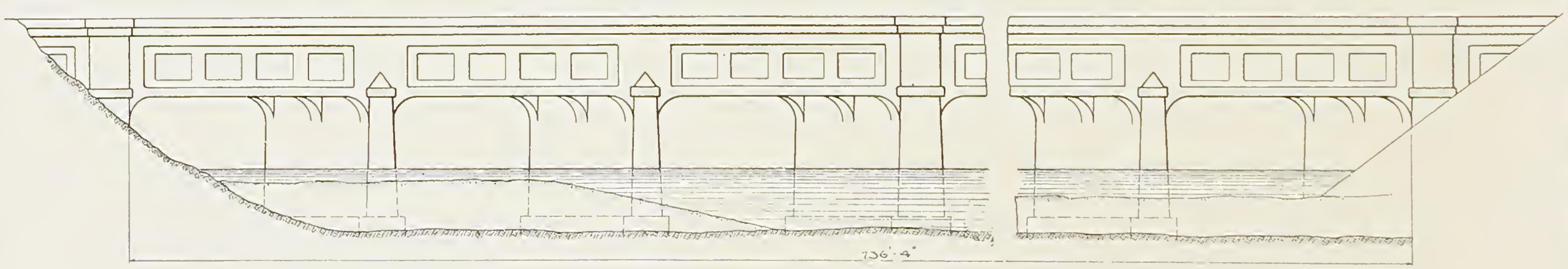
Hannan and Hickey, Contractors.



This is no doubt the highest reinforced concrete abutment of this type that has been built. The height from the base to the top of the parapet is 61′ 6″.







PART ELEVATION

FRENCH BROAD CREEK VIADUCT, SOUTHERN RAILWAY.

W. H. Wells, Engineer Construction. W. B. Crenshaw, Assistant Engineer. W. H. Burk, Designing Engineer.

Double track viaduct, 22 skew spans.

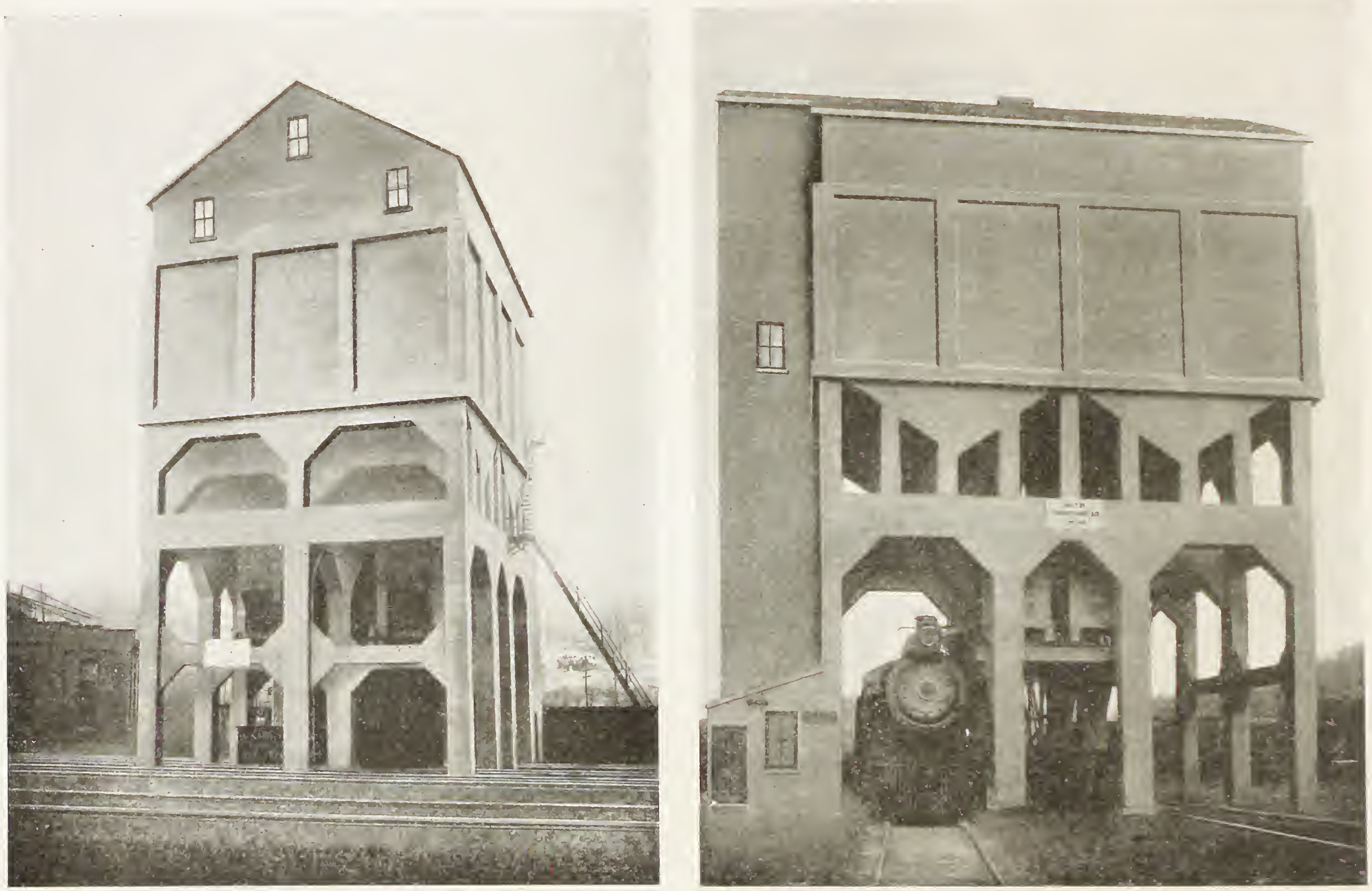
FLOOR SUBWAY AND CONSTRUCTION, LOCOMOTIVE SHOPS AT SCRANTON, PA., DELAWARE, LACKAWANNA & WESTERN R. R.

LINCOLN BUSH, Chief Engr.

H. C. BOWDEN AND B. H. DAVIS, Des. Engrs.

C. J. RAY, Division Engr.

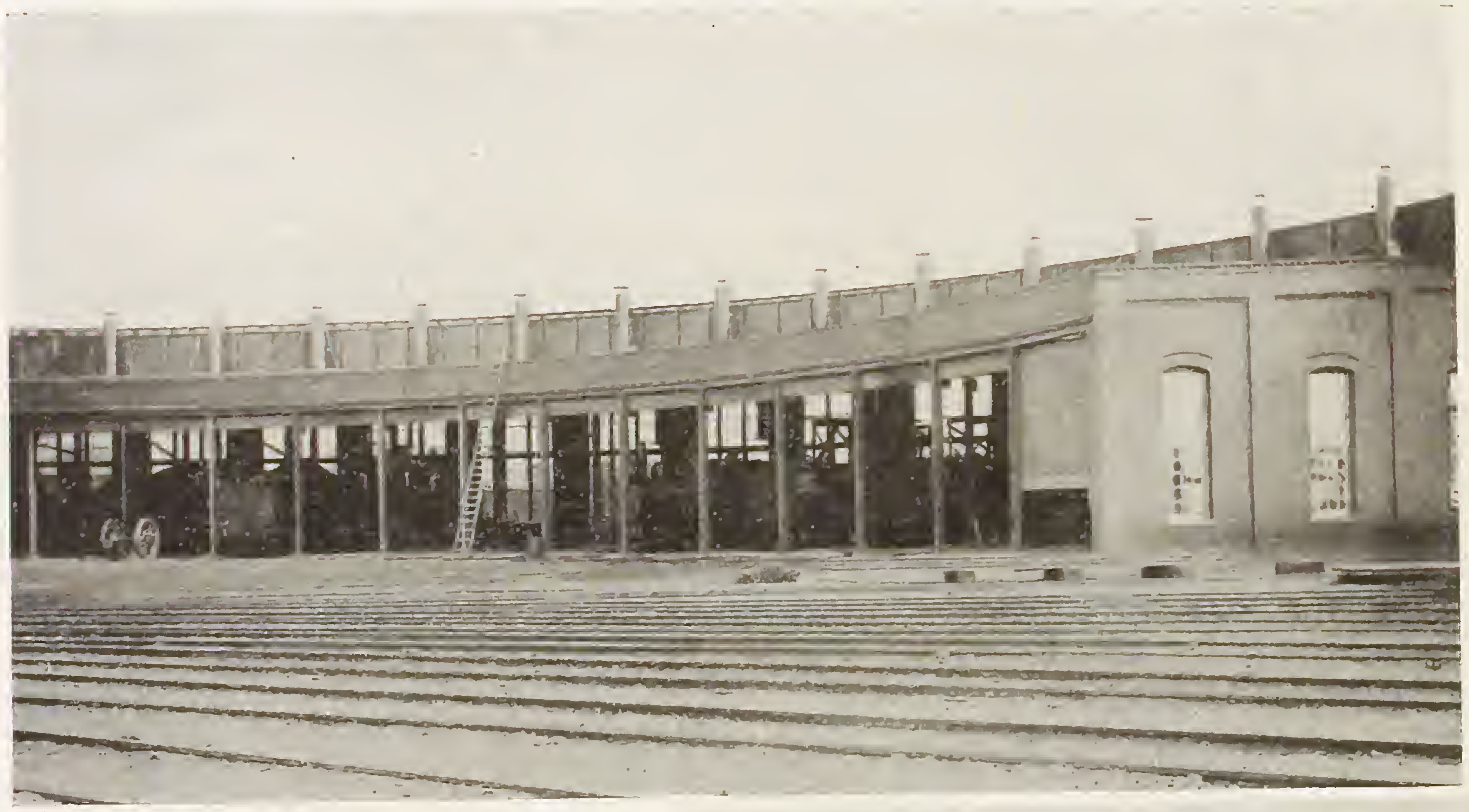
Floors and subway roof designed for load of 700 lbs. per square foot.



COAL AND SAND STATION, SOUTHERN RAILWAY, ASHEVILLE, N. C.

Fairbanks-Morse and Co., Engineers and Contractors.

Capacity: Coal, 1,000 tons; Sand, 100 tons.



REINFORCED CONCRETE
ROUND HOUSE,
D. & R. G. R. R.,
BURNHAM, COLORADO.

E. J. Yard, Chief Engineer.

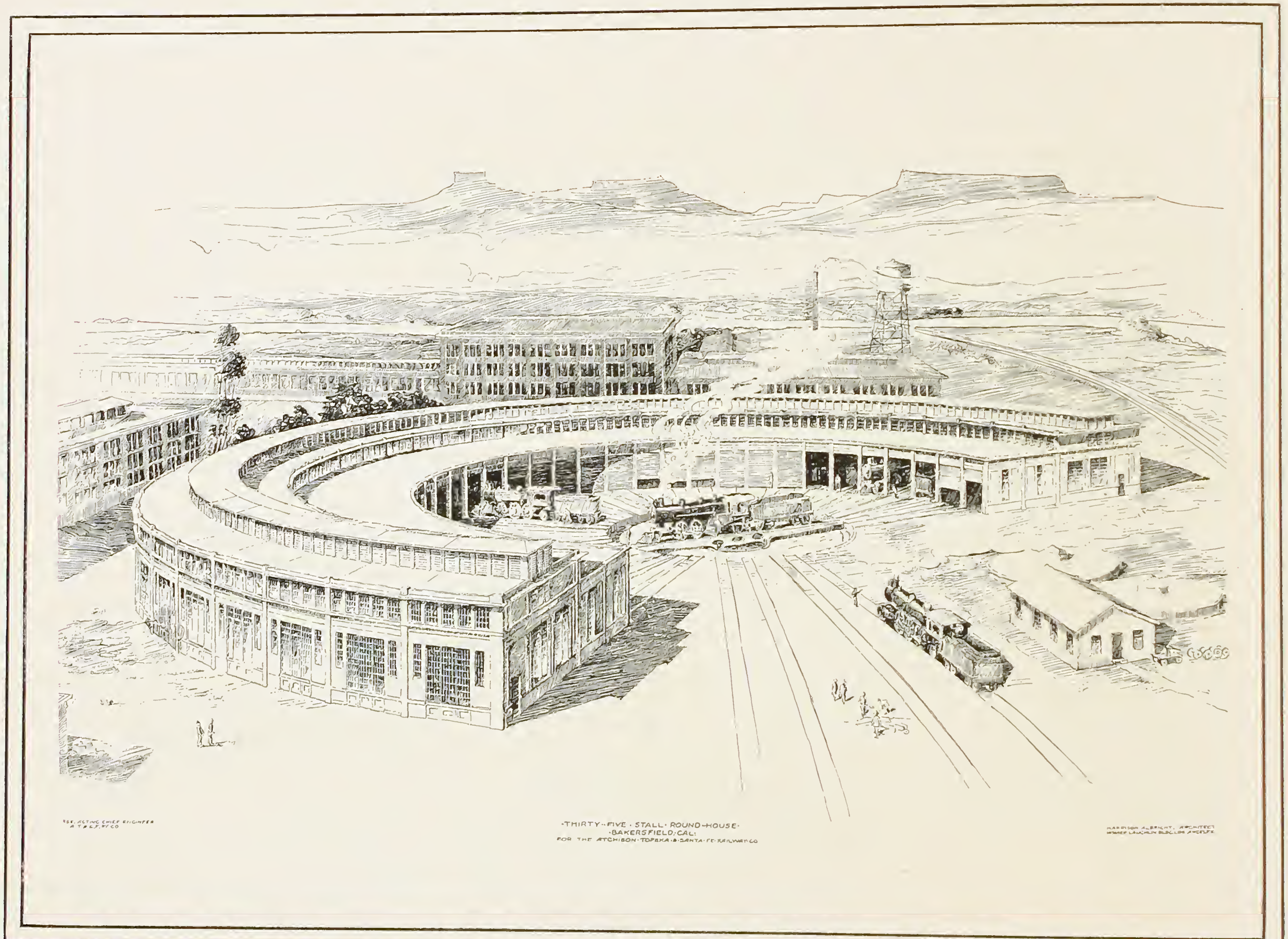
Arthur Ridgway, Acting Engineer B. & B.

All concrete construction excepting columns and end wall.

REINFORCED CONCRETE
BLACKSMITH SHOP,
C., M. & ST. P. RY.,
AT MILWAUKEE, WIS.

C. F. Loweth,
Engineer and Superintendent B. & B.

J. J. Harding, Engineer of Masonry.



ROUND-HOUSE—SANTA FE RAILWAY CO., BAKERSFIELD, CAL.

HARRISON ALBRIGHT, Architect. C. A. MORSE, Acting Chief Engineer, A., T. & S. F. RY. C. LEONARDT, Contractor.

All concrete construction; over-all dimensions, 92′ radially, 950′ along outside circle.

Miscellaneous Structures.

UNDER this heading are included such constructions as highway bridges, viaducts, reservoirs, canals, tunnels, sewers, dams, etc. The permanence and reliability of concrete reinforced with the Corrugated Bar, not to mention the economy that can be effected in most cases, make it especially desirable for public improvement work, and, in fact, for all construction when the above qualities, combined with practically no maintenance charges are to be considered. One of the great advantages of reinforced concrete, making it especially suitable for waterworks constructions and long retaining walls, is that, when properly reinforced, it will not develop cracks from shrinkage, temperature or other contributory causes. The high elastic limit and great bonding value of the Corrugated Bar makes it beyond question the best and most economical reinforcement for such use.

The illustrations following are intended to show a variety of structures in which the Corrugated Bar was used, and we have endeavored to select typical constructions rather than striking or imposing works.

RIPON BRIDGE, ACROSS THE STANISLAUS RIVER, STANISLAUS, CO., CAL.

F. E. QUAIL AND A. L. FINNEY CO., Engineers. JNO. B. LEONARD, Consulting Engineer. PACIFIC CONSTRUCTION CO., Contractors.

Highway bridge, two 100′ spans; width of roadway 18′.

NEW CHURCH STREET BRIDGE, RAHWAY, N. J.

JACOB L. BAUER, County Engineer. Span 61′ 4″. ARTHUR E. SMITH, Contractor.

MADISON AVE. BRIDGE AND DAM ACROSS TURTLE CREEK, DALLAS, TEX.

N. Wirenskiold, Consulting Engineer.

Reinforced concrete arch, 50′ span.

Concrete-Steel Engineering Co., Contractors.

GRANITE BRANCH BRIDGE,
N. Y., N. H. AND H. R. R.,
WEST QUINCY, MASS.

Metropolitan Park Commission.

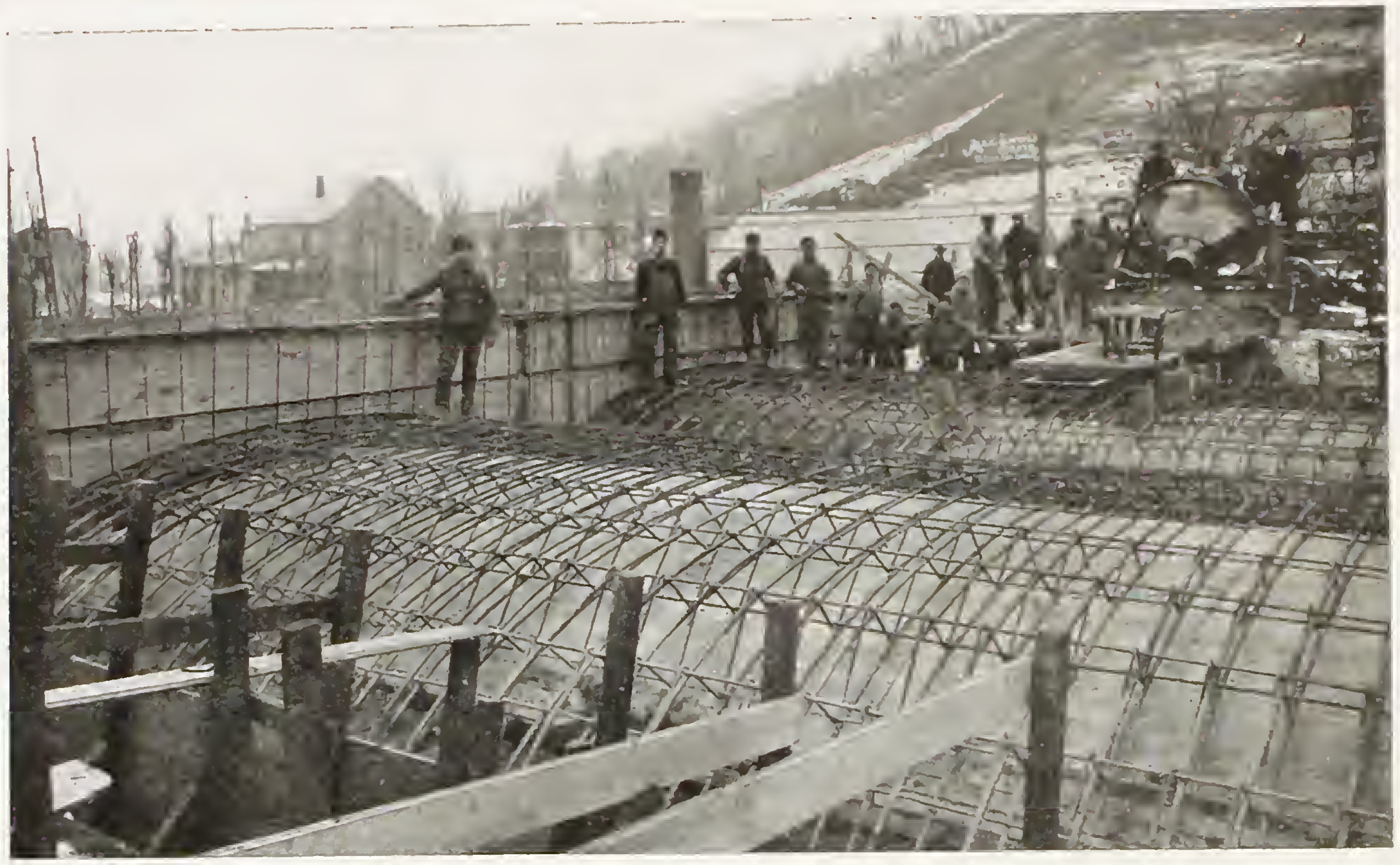
J. R. Rablin, Chief Engineer.

GRAVERS LANE BRIDGE, PHILADELPHIA;

H. H. Quimby, Engineer.

John McMenamy, Contractor.

Clear span of arch, 35′-8″; width of roadway, 30′, sidewalks, 8′-6″. Heavy city loading.



Arches designed for heavy interurban electric cars. The upper illustration shows the arch reinforcement in place.

LAKEMONT PARK BRIDGE, ALTOONA AND LOGAN VALLEY ELEC. R. R.

H. C. HINCKLE, Supt. of Construction.

Two elliptical arches, seventeen feet clear span.

PIKE RIVER ARCH, RACINE, WISCONSIN,
CHICAGO AND MILWAUKEE ELECTRIC
RAILWAY COMPANY.

GIRDER BRIDGE ACROSS RAVINE,
U. S. NAVAL STATION, GREAT LAKES,
NORTH CHICAGO, ILL.

GEO. A. MCKAY, Engineer.

WALLACE MARSHALL, Contractor.

180′ long x 46′ wide. Floor slabs reinforced with corrugated bars; designed for 10-ton road roller.

BRIDGE OVER NORTH TRUNK CANAL, AMERICAN RIO GRANDE LAND AND IRRIGATION CO.

Four twenty-foot spans and one eight-foot span.

IRRIGATION WORKS AMERICAN RIO GRANDE LAND AND IRRIGATION CO.

CHESTER B. DAVIS, Engineer.

REINFORCED CONCRETE CONDUIT.

Four parallel tubes, moulded in mass, each 7′ 9″ inside diameter; length 600′. Normal capacity 1000 cu. ft. per sec. Maximum static head above center of conduit 26 feet.

Views taken during construction. The lower illustration shows the method used for driving the piles.

BOARD WALK
AT
LONG BEACH, LONG ISLAND.

This walk will be $5\frac{1}{2}$ miles long, built entirely of reinforced concrete, and supported by reinforced concrete piles.

Views show the construction of the side walls of the basin, also the method used for handling materials. Buttresses are 18″ thick and spaced 16′ on centers.

SETTLING BASINS, CHAIN OF ROCKS, ST. LOUIS, MO.

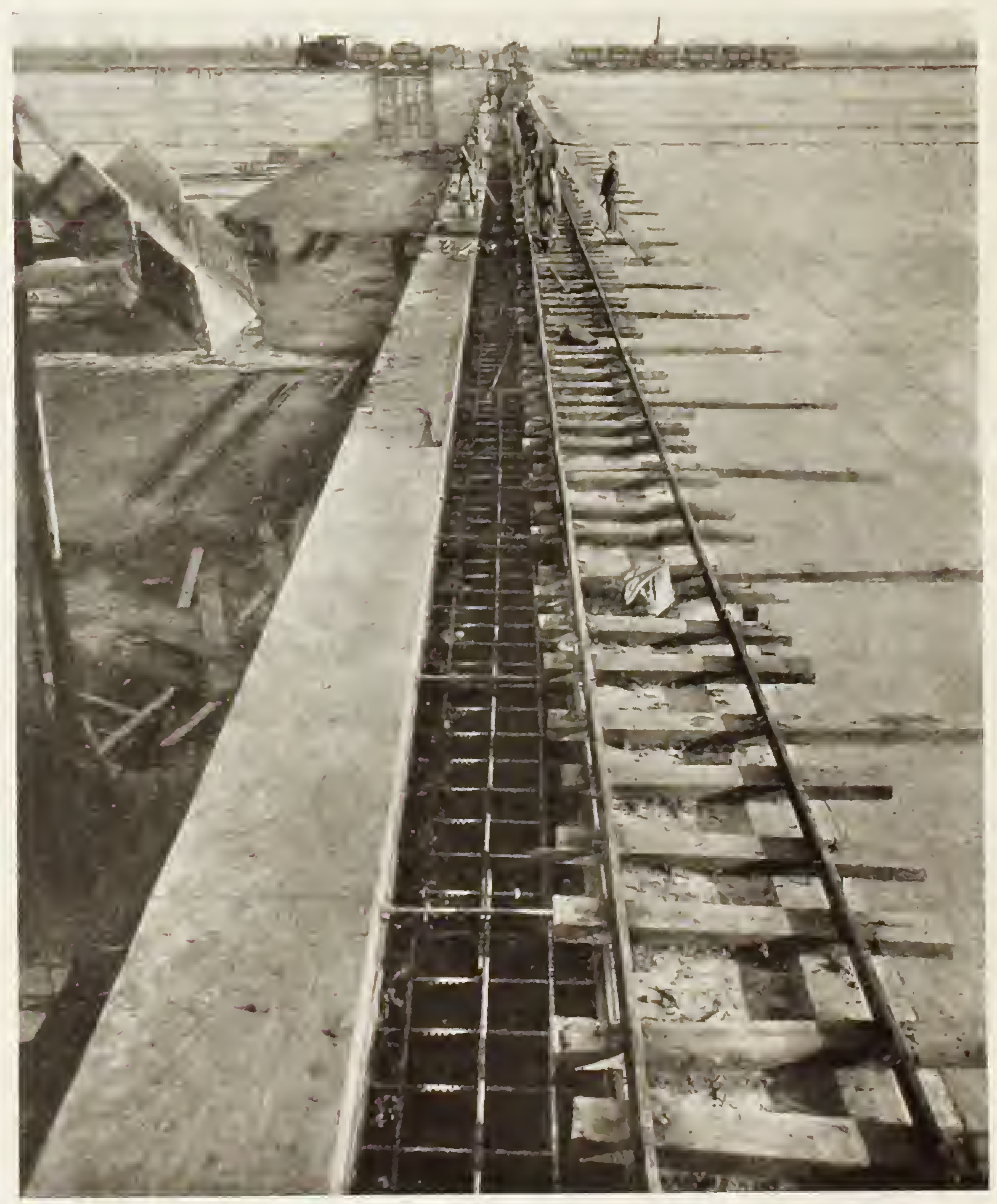
BEN C. ADKINS, Water Commissioner.

E. E. WALL, Asst. Water Commissioner.

FRUIN-COLNON CONST. Co., Contractors.

There are two basins, each 826′-9¾″ long by 400′ wide; average height of walls 25′.

View showing dividing wall between basins. Double concrete walls filled in between with puddle.



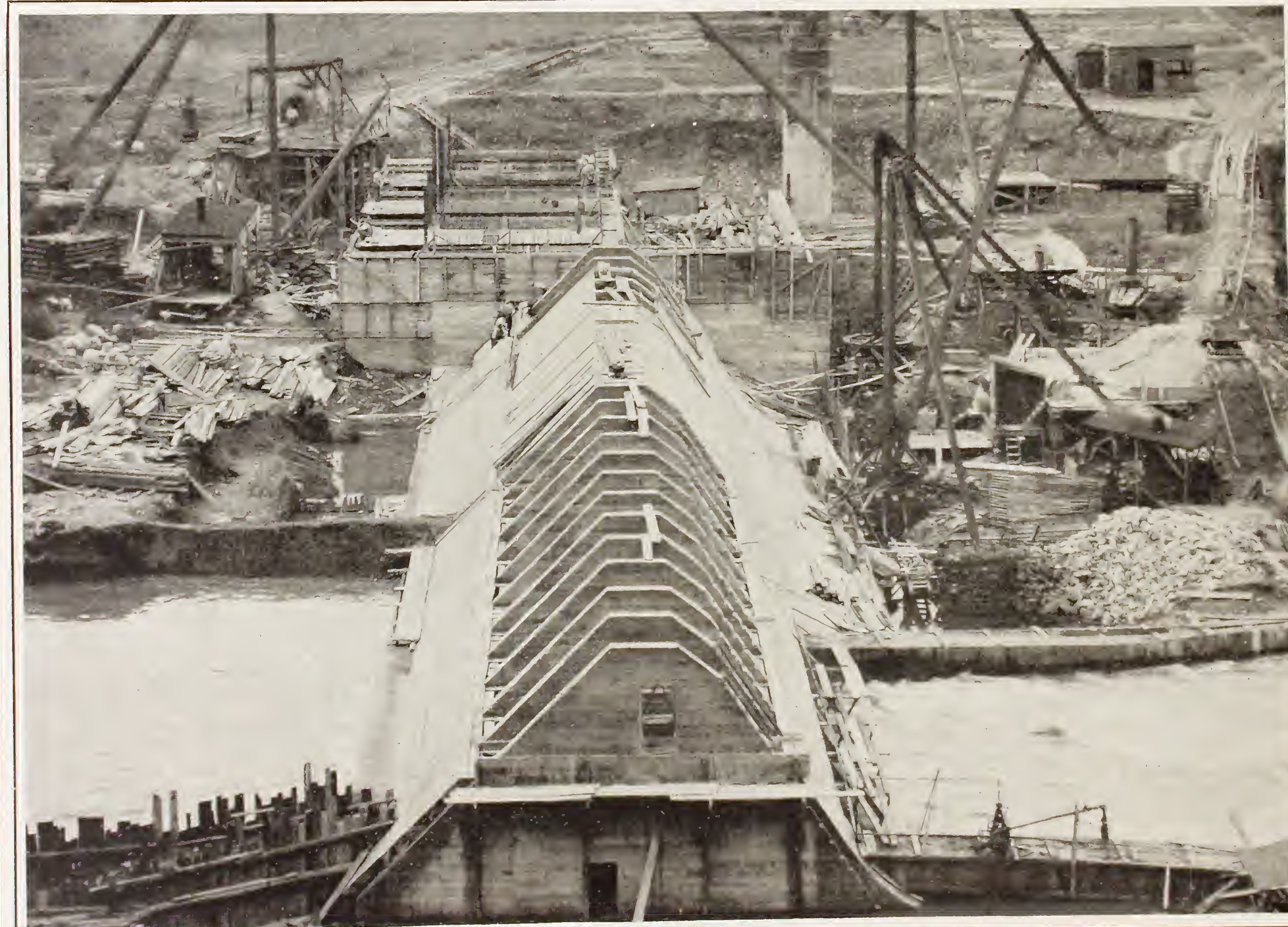
CONSTRUCTION VIEWS,

SETTLING BASINS, ST. LOUIS.

REINFORCED CONCRETE DAM, DELLWOOD PARK, JOLIET, ILL.

PUTNAM, COX & SKINNER, Consulting Architects. AMBURSEN HYDRAULIC CONSTRUCTION Co., Engineers and Contractors.

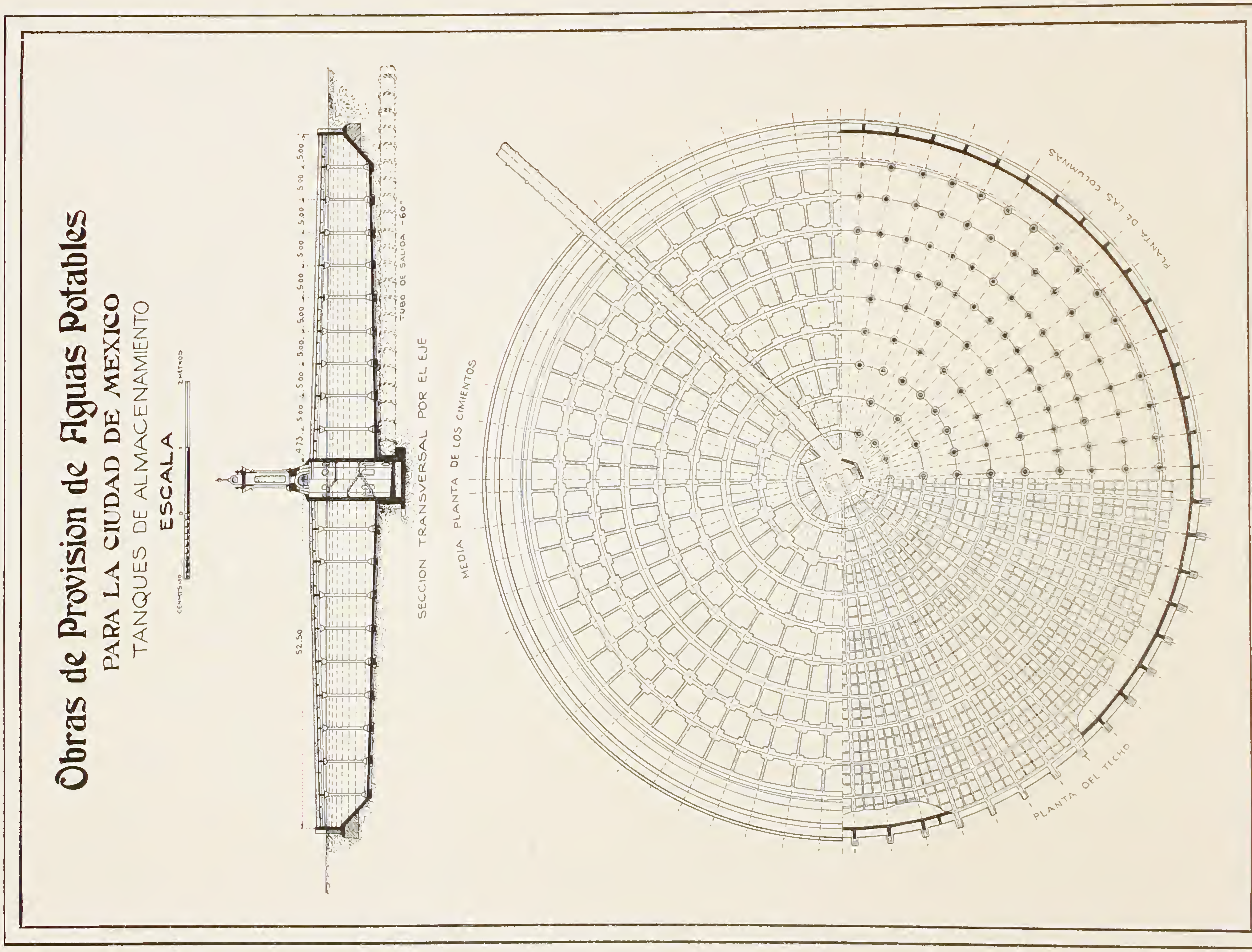
 Total length 160′, spillway 84′; average height 21′. A foot bridge through the dam affords a means of crossing over.



FULL APRON SPILLWAY DAM, HUNTINGDON, PA., WARRIORS' RIDGE STATION.

AMBURSEN HYDRAULIC CONSTRUCTION CO., Engineers and Contractors. JUNIATA HYDRO ELECTRIC CO., Owners.

Length between abutments, 375'; maximum height, 30'; buttresses, 10' on centers.



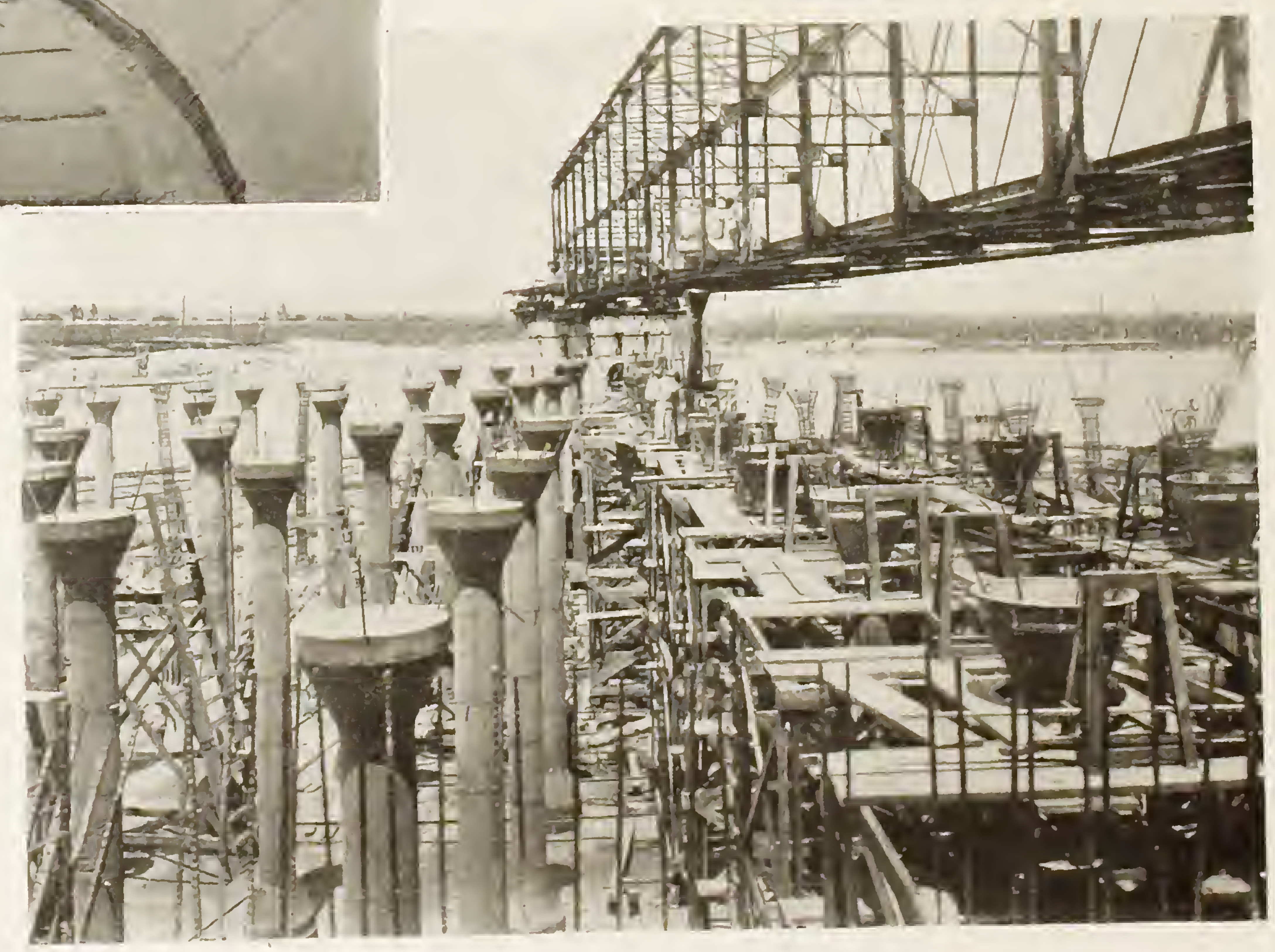
RESERVOIR CONSTRUCTION—CITY OF MEXICO.

The roof system will carry, in addition to its own weight, a layer of earth 20″ thick, which will be sodded. The lower view shows the sheet metal moulds for the columns, also bridge used for handling concrete and materials.

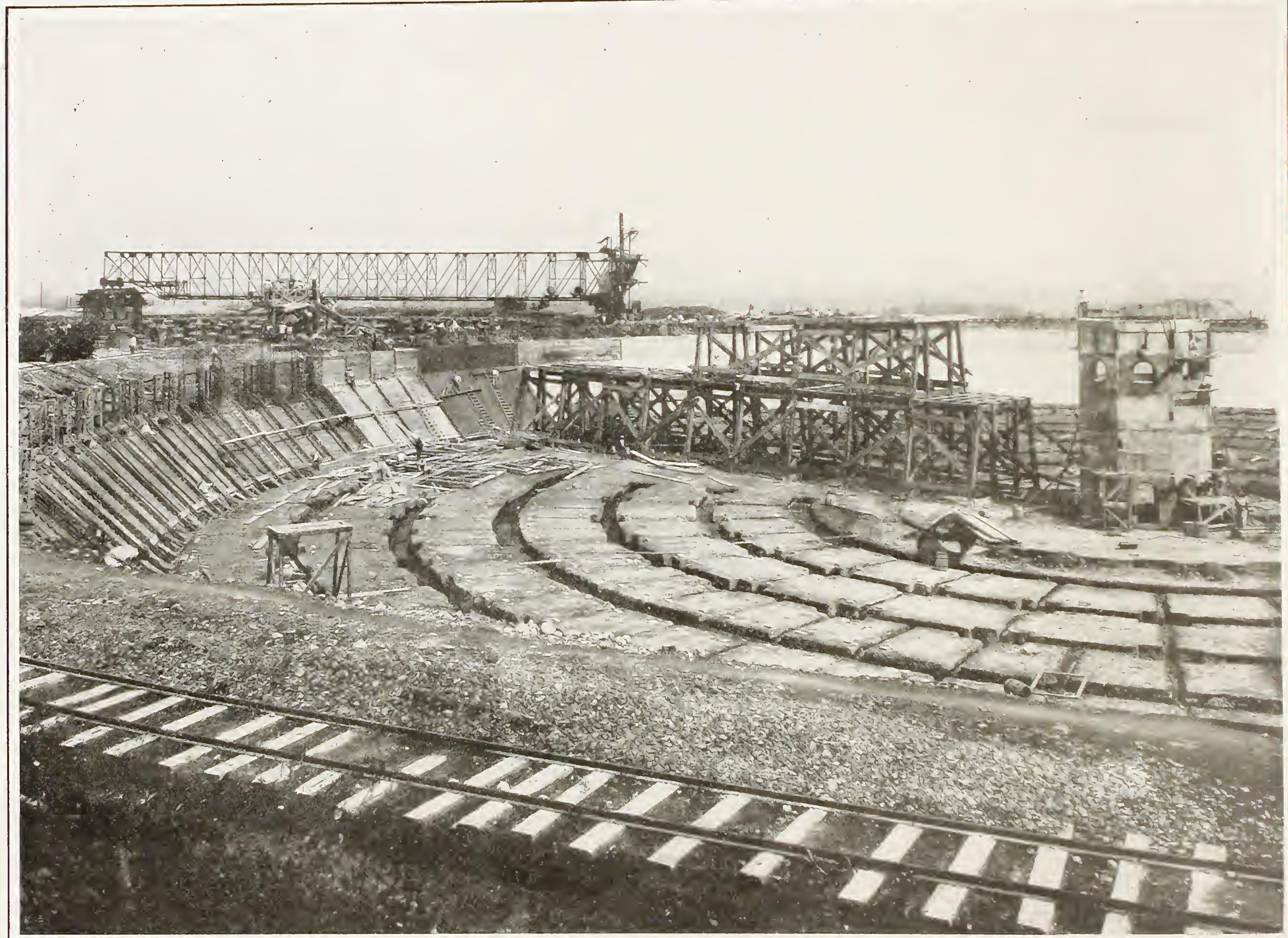
RESERVOIR CONSTRUCTION,
CITY OF MEXICO.

JUNTA DIRERTIVA
DE LAS OBRAS DE PROVISION DE AGUAS.
JOSE I. LIMANTOUR, President.
LEANDRO FERNANDEZ, Vice-President.
MANUEL MARROQUIN Y RIVERA, Engineer.

There are four circular reservoirs 105 meters in diameter, constructed entirely of reinforced concrete — floors, side walls, columns and roofs.



RESERVOIR CONSTRUCTION—CITY OF MEXICO.



RESERVOIR CONSTRUCTION—CITY OF MEXICO.

View shows excavation for column bases and floor girders; construction work on side walls, and the intake tower in the center of the tank.

GATES AND GATE HOUSE
SUNNYSIDE DAM,
YAKIMA PROJECT, WASHINGTON.

United States Reclamation Service.

ROCK FACED
REINFORCED CONCRETE ARCH,
JACKSON PARK, CHICAGO.

Linn White, Chief Engineer.

Block Bridge & Culvert Co., Contractors.

SEWER AT BROOKLYN, N. Y.

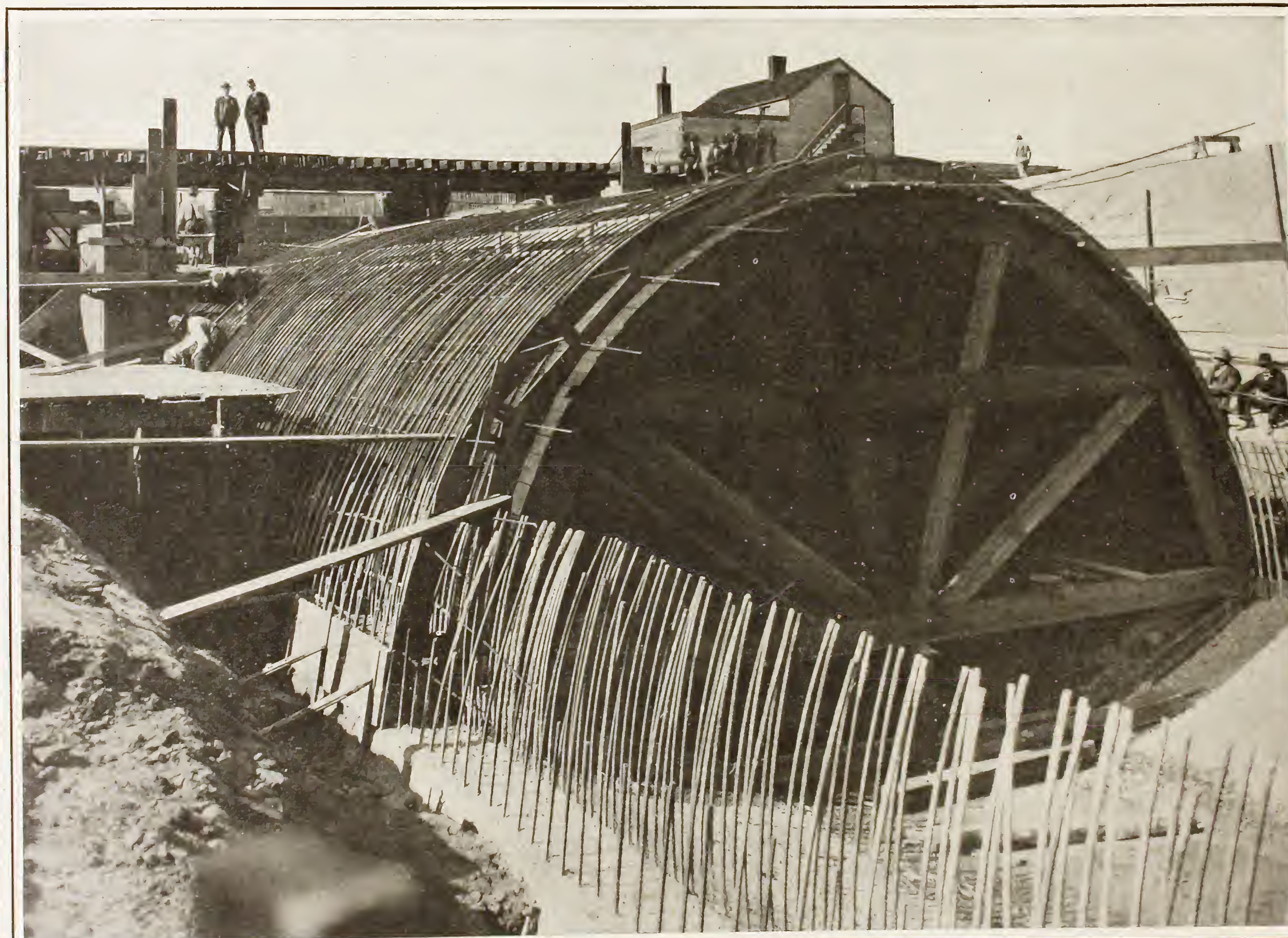
Sigretto and Manning Co., Contractors.

Blaw Collapsible Steel Centering used.

SEWER AT DALLAS, TEXAS.

Municipal Paving Co., Contractors.

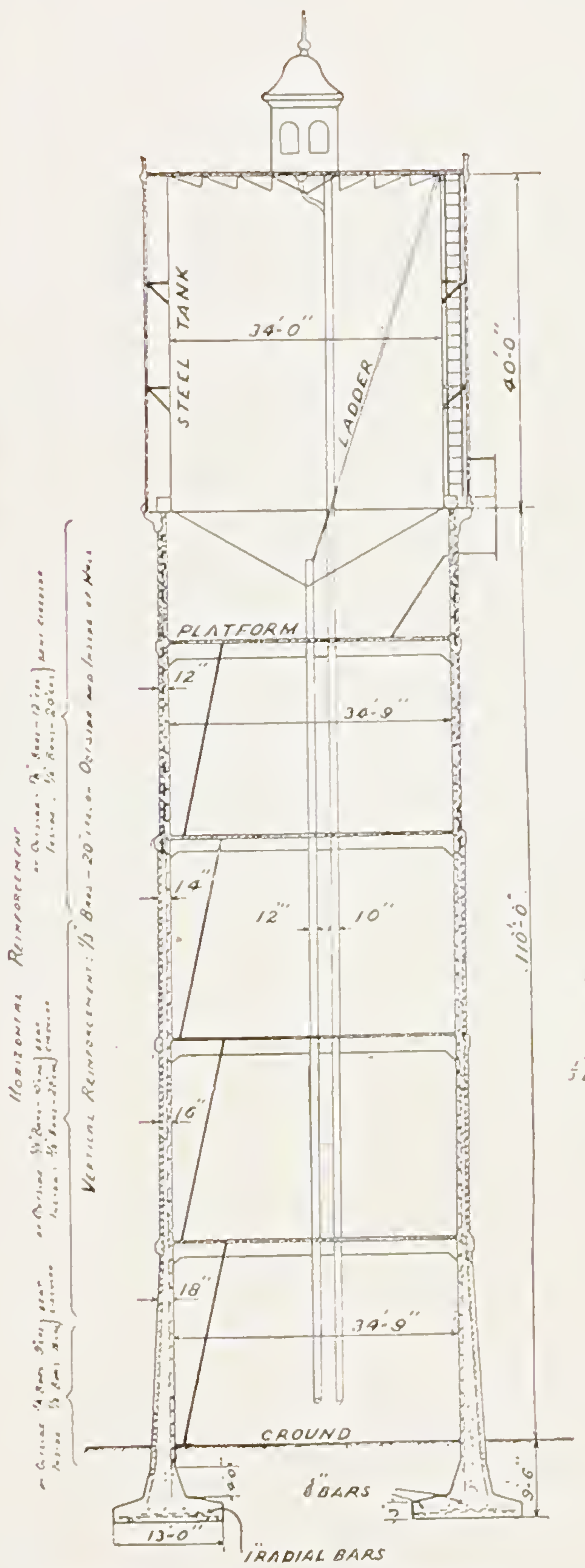
Blaw Collapsible Steel Centering used; circular section, diameter 5 feet.



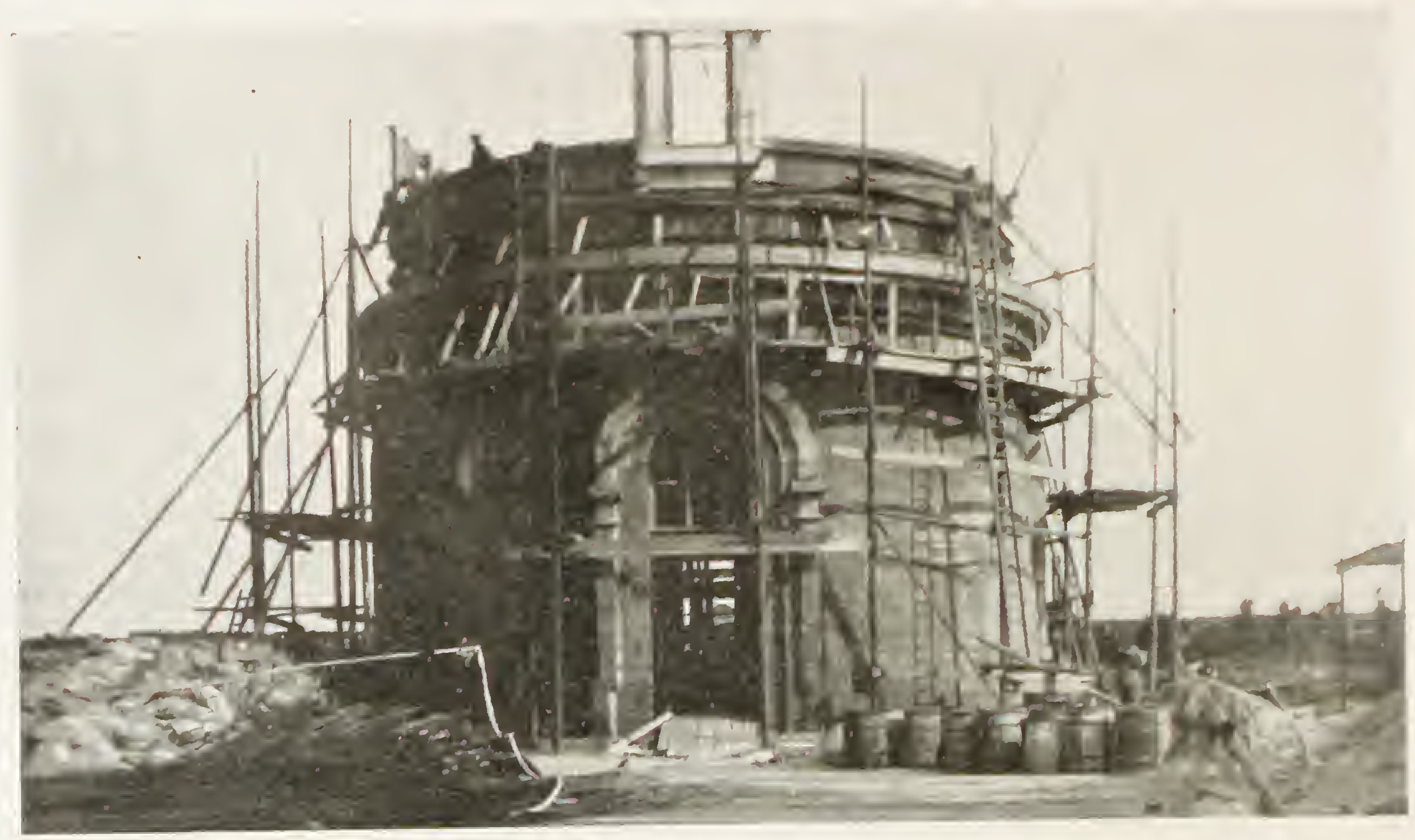
HARLEM CREEK PUBLIC SEWER, ST. LOUIS.

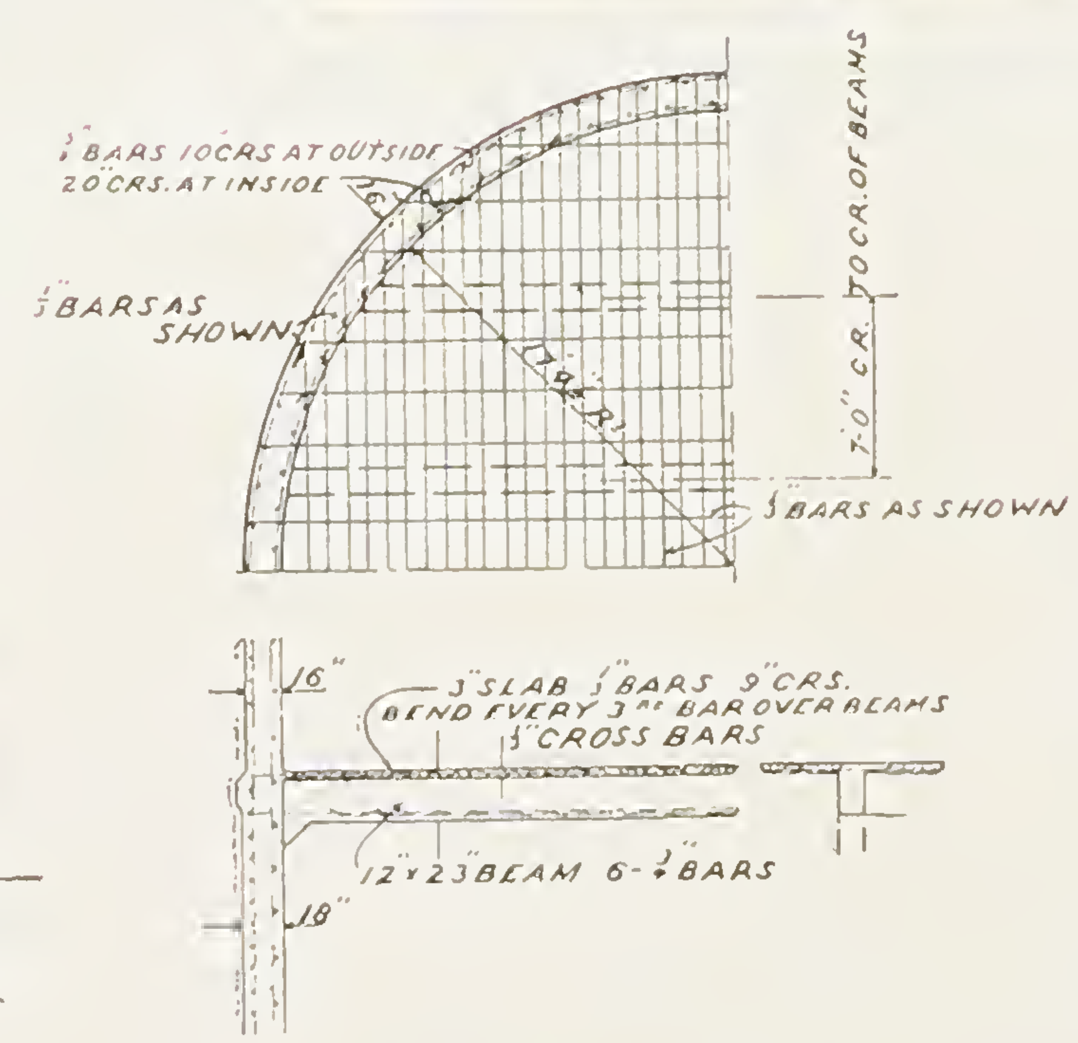
H R. FARDWELL, Sewer Commissioner. J. A. HOOKE, Asst. Sewer Commissioner. HOFFMAN AND HOGAN, Contractors.

Length 4,800′. Clear span 29′ lower end, 25′ upper end. Height 19′ and 18′. Designed for 15′ fill.



TYPICAL SECTION OF TOWER





DETAIL OF PLATFORMS

VIEW OF TOWER CONSTRUCTION UP TO FIRST FLOOR.

It is popularly supposed that Reinforced Concrete does not lend itself to architectural effect.

Note the heavy mouldings, which are all made of reinforced concrete.

CLEETHORPES TOWER, GREAT GRIMSBY WATERWORKS CO.

HENRY HEWINS, Engineer. FERBECK CHIMNEY CONSTRUCTION CO., Contractors.

Construction views in section of subway around City Hall.

SUBWAY CONSTRUCTION
PHILADELPHIA RAPID TRANSIT COMPANY
PHILADELPHIA, PA.

WM. S. TWINING, Chief Engineer.

E. E. SMITH CONTR. CO., Contractors.

REINFORCED CONCRETE BULKHEAD,
BRUNSWICK STEAMSHIP CO.,
BRUNSWICK, GA.

Fore River Ship Building Co.

M. M. Cannon, Engineer.

W. L. Miller, Contractor.

Construction view, showing driving of concrete piles.

THIRD STREET BRIDGE OVER
HYDRAULIC CANAL,
NIAGARA FALLS, N. Y.

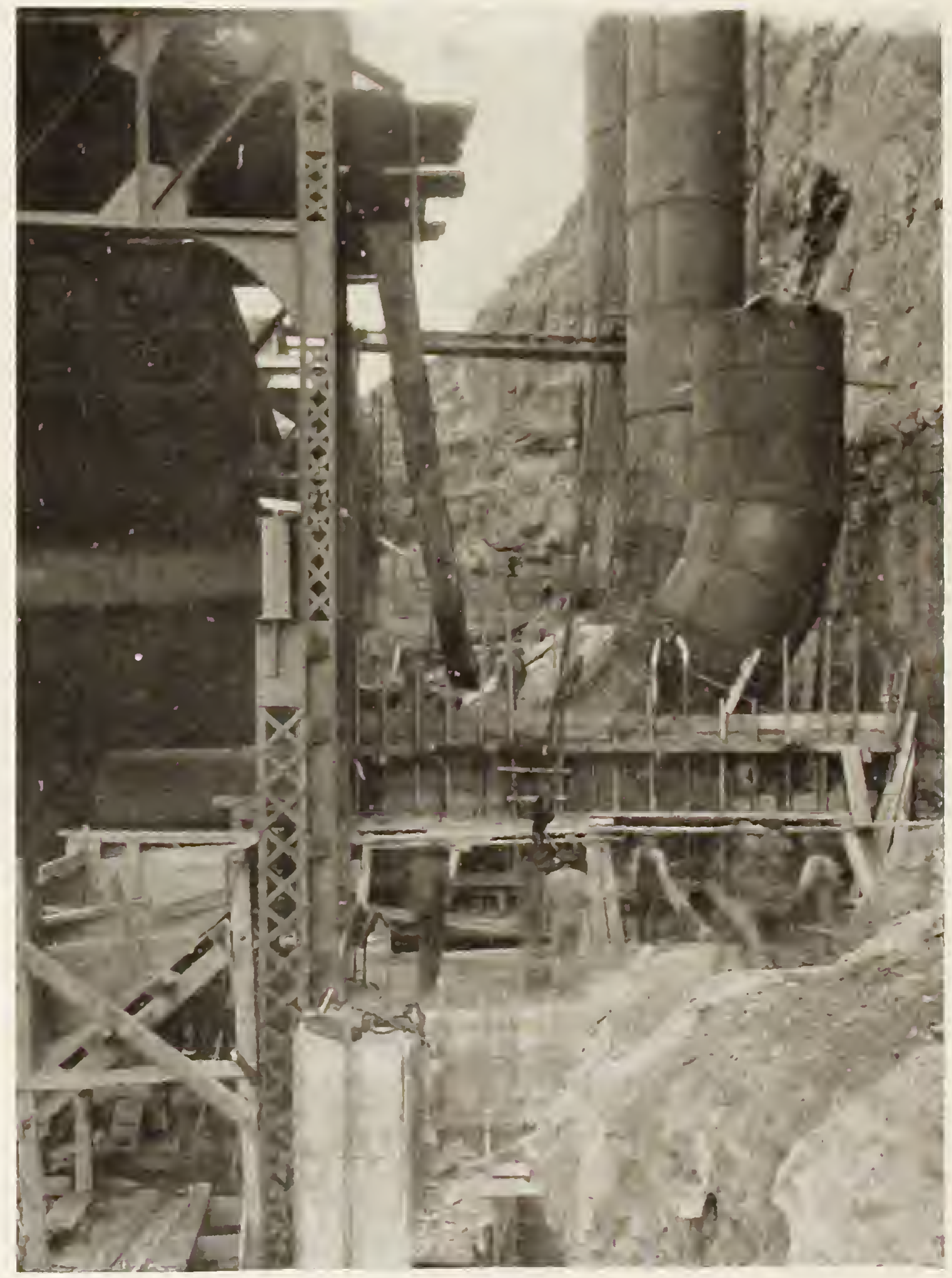
Niagara Falls Hydraulic Power
and Manufacturing Co.,
John L. Harper, Chief Engineer.

W. W. Read, City Engineer.

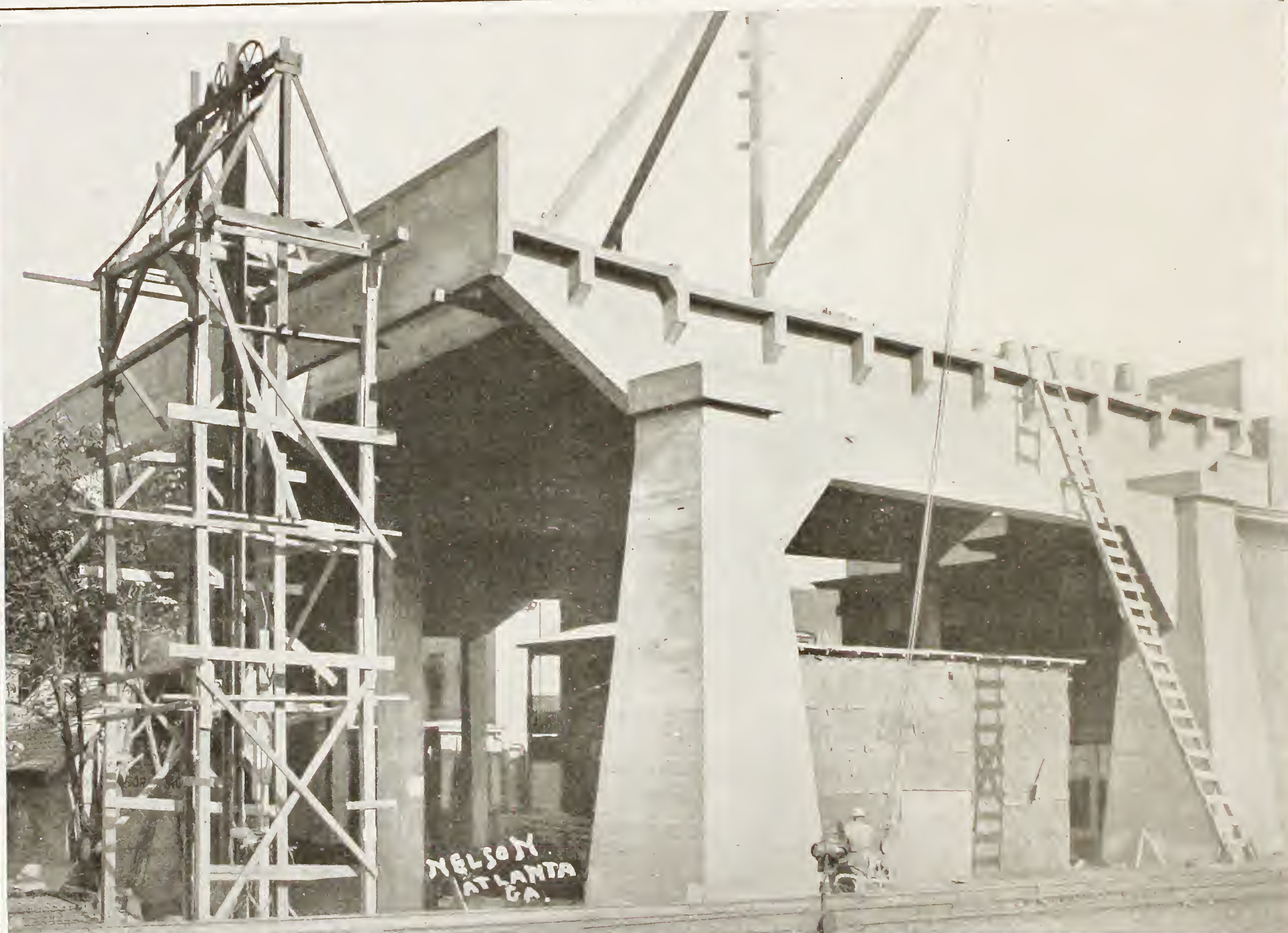
FLUME CONSTRUCTION.

CONSTRUCTION VIEWS
NIAGARA FALLS HYDRAULIC POWER AND
MANUFACTURING CO.,
NIAGARA FALLS, N. Y.

JOHN L. HARPER, Chief Engineer.



Steel penstocks surrounded by reinforced concrete. The illustration shows some of the reinforcing bars in place.



END VIEW—WASHINGTON STREET VIADUCT, ATLANTA, GA.

W. H. Burk, Engineer. The Oliver Co., Contractors.

All reinforced concrete design. Over all dimensions, 60'x960'; spans vary in length up to 40 feet.

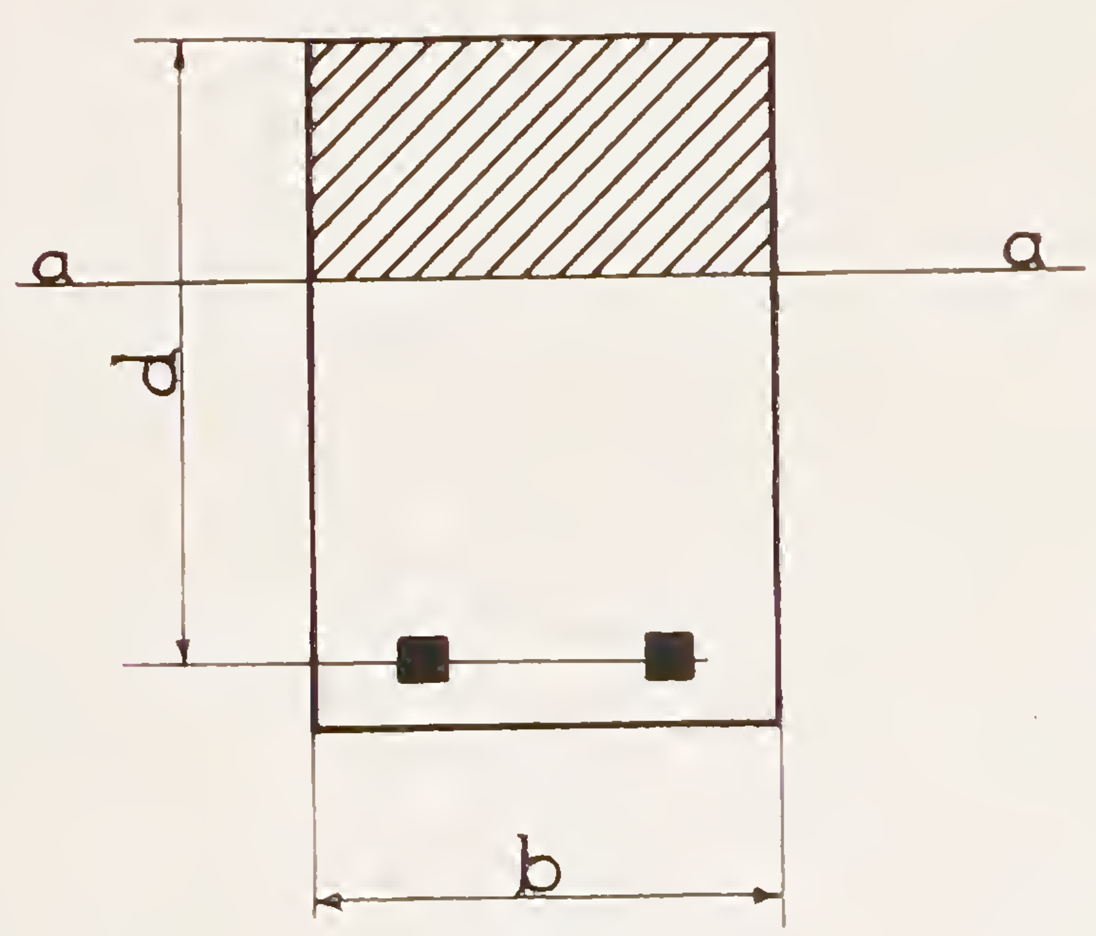
The Strength of Reinforced Concrete Beams.

THE question of the strength of reinforced concrete beams, in so far as resistance to flexure is concerned, has been discussed so often, that various analyses are familiar to those who are interested in this construction, and it is not proposed to give a full discussion here. The practical designer needs a formula that will give results closely approximating the actual strength of the beam without especial regard as to just how the particular formula was derived. We recommend that the beam be designed for its breaking load, as the proper constants for any given analysis can readily be determined at this stage by practical tests; moreover the effect of the tensional resistance of the concrete is then negligible and can be properly omitted from the mathematical discussion. If the beam is figured for working loads or for arbitrarily chosen stresses in the concrete and steel, the tensile resistance of the concrete has a very appreciable effect on the deformation and deflection of the beam; thus making it extremely difficult to check the assumed stresses by experiments.

With a given percentage of metal and a particular concrete the breaking strength of the beam can be closely predicated, and there is no advantage in knowing what the working stresses are. We recommend ordinarily that the percentage of metal be so chosen that the beam is equally strong in tension and compression, figuring the steel at its elastic limit stress; a beam so reinforced is said to have the critical percentage of metal.

The ultimate moment of resistance of a reinforced concrete beam can be obtained by substituting the proper values in an equation of the form, $M_0 = Kpbd^2$.

Let the accompanying figure represent the cross section of a reinforced concrete beam, the shaded area above the neutral axis, *a-a*, being the area of the compressive stresses.



E_s=Modulus of Elasticity of the steel.

E_c=Initial Modulus of Elasticity of the concrete in compression.

F=Elastic limit of the steel.

f_c=Ultimate compressive strength of the concrete.

q=Area of metal in width b.

p=Ratio of reinforcement in terms of bd=area of metal (q) divided by the cross section of the beam above the plane of the metal (bd).

M_o=Ultimate Moment of Resistance of the beam in inch pounds.

K, a constant for any given concrete.

All dimensions in inches and all stresses in pounds per square inch.

It is well known that we cannot utilize any of the strength of the steel beyond the elastic limit, and it is accordingly desirable to have this limit fairly high. Corrugated bars have an elastic limit of from 50,000 to 65,000 pounds, and we may use as the constants for steel, E_c=29,000,000 and F=50,000.

The following formulae then give **ultimate strength** of beams reinforced with the critical percentage of **Corrugated Bar** reinforcement. For the convenience of designers the various grades of concrete have been arbitrarily divided into three classes, and care should be used so that the proper formula for the particular case in hand is used:

Class No. 1, Average Rock Concrete.

This class is meant to include all concretes having a compressive strength of 2000 lbs. per square inch; f_c then=2000 and taking E_c=2,600,000, we get for the ultimate resisting moment;

$$M_o=370\ bd^2 \text{ for } q=.0085\ bd \ldots\ldots\ldots\ldots (1)$$

Class No. 2, Good Rock Concrete.

By using a 1: 2: 4 mix and good rock or gravel we get a concrete of much greater compressive strength, but with a higher modulus of elasticity. For such a concrete we may assume E_c=2,800,000 and f_c=2700, and we get;

$$M_o=570\ bd^2 \text{ for } q=.0132\ bd \ldots\ldots\ldots\ldots (2)$$

Class No. 3, Cinder Concrete.

For a 1 : 2 : 5 mix of cinder concrete we may assume E_c=750,000 and f_c=750, we then have;

$$M_o=205\ bd^2 \text{ for } q=.0047\ bd \ldots\ldots\ldots\ldots (3)$$

General Formula for Rock Concrete.

The ultimate strength of reinforced concrete beams reinforced with any percentage of metal, **so long as the reinforcement is kept below the critical percentage for the particular concrete used** may be expressed by a general formula as follows:

$$M_o=.86\ F\ p\ bd^2 \ldots\ldots\ldots\ldots (4)$$

Example—What size beam is required for an ultimate moment (live and dead load moments times factor of safety) of 1,500,000 inch lbs., assuming average rock concrete.

$$M_o=1,500,000=370\ bd^2.\text{—(Formula No. 1).}$$

Assuming $b=10''$ and solving for d we get $d=20''$. Area of metal required=q=.0085 bd=1.70 sq. inches; say three $\frac{3}{4}''$ N. S. corrugated bars. The distance d is from the top of the beam to the plane of the metal; there would be about 2″ of concrete below the metal, making the outside dimensions of the beam 10″x22″.

FORMULAE BASED ON WORKING STRESSES.

It is sometimes required, and certain municipal ordinances demand, that reinforced concrete beams be designed, using certain specified working stresses in the concrete and steel, and an assumed constant ratio between the moduli of elasticity of the two materials. While we do not advocate such practice, and in fact most experiments tend to show that the stresses, ordinarily specified, do not occur simultaneously, we give the following brief discussion of the matter:

By arbitrarily choosing the unit stresses in the concrete and steel, and the ratio of the moduli of elasticity, we fix the percentage of reinforcement.

Let $n=\frac{E_s}{E_c}$, s=unit stress in steel, and c= unit stress in concrete.

Assuming $n=15$, $c=500$, $s=16,000$, and neglecting the tensional value of the concrete in resisting flexure, we have, assuming a rectilinear relation between stress and strain for the concrete,

$$M_r=70\ bd^2 \text{ for } q=.005\ bd \qquad (5)$$

For $n=12$, $s=16,000$ and $c=800$ we have as before.

$$M_r=130\ bd^2 \text{ for } q=.0096\ bd \qquad (6)$$

The strength of reinforced concrete beams may be assumed to be directly proportional to the percentage of reinforcement as long as the amount of steel is kept below that required to cause failure by compression in the concrete. With the proportion of metal below the critical percentage then, the stress in the steel need only be considered, and a very simple formula results. The distance from the plane of the metal to the center of

the compressive stresses may be taken as .86 d for all ordinary percentages of reinforcement. The moment of resistance then becomes;

$$M_r = sq \times 0.86\ d \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Note, in applying this formula, that the unit stress in the steel, s, should in no case be greater than $\frac{1}{3}$ of the elastic limit of the metal; and q, using high elastic limit Corrugated Bars, must be less than .0085 bd for average rock concrete or .0132 for good rock concrete.

If ordinary commercial steel is used, considerable more metal is required to develop the compressive strength of the concrete and q should then be less than .0125 bd for average rock concrete and not greater than .02 bd for good rock concrete.

Example—Given $n=12$, $s=16,000$, and $c=800$; what size of beam is required to carry a load (including dead load) of 1000 lbs. per ft. run, on a span of 16′? Beam considered as simply supported at the ends.

The bending moment at the cènter of the beam then$=M_r=\frac{1}{8} \times 1000 \times 16^2 \times 12=$ 384,000 in. lbs.

Assuming $d=20''$, we get by substitution in formula No. 6, $b=7.4''$, and from the equation, $q=.0096\ bd$, we get the area of metal required=1.4 sq. inches.

TABLES FOR USE IN DESIGNING REINFORCED CONCRETE BEAMS.

For convenience in designing, Table No. 1, page 106, has been prepared, which gives the necessary depth and the amount of reinforcement required for beams 12″ wide (of either average or good rock concrete), corresponding to the ultimate resisting moments given. Table No. 2 gives the spacing of different sizes of corrugated bars, corresponding to a given area of metal per foot width.

Table No. 1.

TABLE FOR USE IN DESIGNING REINFORCED CONCRETE BEAMS. 12″ WIDE.

$M_o = 370\ bd^2$. $q = .0085\ bd$.

AVERAGE ROCK CONCRETE.

M	d	q	M	d	q
50	3.36	0.343	3000	25.97	2.648
75	4.12	.420	3250	27.05	2.760
100	4.74	.484	3500	28.06	2.861
150	5.81	.593	3750	29.05	2.962
200	6.71	.685	4000	30.00	3.060
250	7.50	.765	4250	30.92	3.157
300	8.22	.840	4500	31.84	3.250
350	8.88	.905	4750	32.70	3.332
400	9.50	.968	5000	33.55	3.418
450	10.06	1.025	5500	35.18	3.590
500	10.60	1.080	6000	36.75	3.745
550	11.12	1.135	6500	38.22	3.900
600	11.62	1.185	7000	39.68	4.050
650	12.09	1.232	7500	41.08	4.190
700	12.55	1.281	8000	42.42	4.330
750	12.98	1.322	8500	43.72	4.455
800	13.42	1.370	9000	45.00	4.590
850	13.82	1.410	9500	46.22	4.718
900	14.23	1.452	10000	47.43	4.840
950	14.62	1.491	11000	49.72	5.075
1000	15.00	1.530	12000	51.95	5.295
1200	16.43	1.675	13000	54.10	5.520
1400	17.75	1.810	14000	56.12	5.725
1600	18.98	1.937	15000	58.10	5.925
1800	20.12	2.050	16000	60.00	6.120
2000	21.21	2.165	17000	61.80	6.310
2250	22.50	2.295	18000	63.60	6.480
2500	23.72	2.418	19000	65.40	6.670
2750	24.88	2.540	20000	67.10	6.850

$M_o = 570\ bd^2$. $q = .0132\ bd$.

GOOD ROCK CONCRETE.

M	d	q	M	d	q
50	2.70	0.428	3000	20.95	3.320
75	3.31	.524	3250	21.78	3.443
100	3.82	.605	3500	22.62	3.582
150	4.68	.742	3750	23.40	3.705
200	5.40	.856	4000	24.17	3.828
250	6.04	.956	4250	24.92	3.950
300	6.62	1.050	4500	25.65	4.063
350	7.15	1.134	4750	26.32	4.170
400	7.64	1.210	5000	27.03	4.282
450	8.11	1.285	5500	28.35	4.490
500	8.54	1.352	6000	29.60	4.691
550	8.96	1.420	6500	30.80	4.875
600	9.36	1.484	7000	32.00	5.070
650	9.74	1.544	7500	33.10	5.245
700	10.10	1.601	8000	34.20	5.422
750	10.46	1.658	8500	35.25	5.580
800	10.81	1.714	9000	36.28	5.741
850	11.15	1.764	9500	37.26	5.901
900	11.47	1.817	10000	38.22	6.050
950	11.78	1.866	11000	40.10	6.355
1000	12.08	1.915	12000	41.85	6.628
1200	13.23	2.100	13000	43.60	6.908
1400	14.30	2.266	14000	45.22	7.165
1600	15.28	2.421	15000	46.80	7.418
1800	16.21	2.570	16000	48.35	7.660
2000	17.09	2.704	17000	49.83	7.892
2250	18.13	2.875	18000	51.30	8.125
2500	19.10	3.025	19000	52.70	8.350
2750	20.03	3.180	20000	54.10	8.570

The moments given in the table are the ultimate moments of resistance of the sections in thousands of inch pounds. To use table first apply desired factor of safety to actual moments.

M=Ultimate bending moment of external forces in thousands of inch pounds=Mo.

d=Distance from top of beam to plane of metal in inches.

q=Number of square inches of metal required in beam, in width of 12 inches.

Table No. 2.

TABLE SHOWING THE NECESSARY SPACING OF DIFFERENT SIZES OF CORRUGATED BARS FOR A GIVEN AREA OF STEEL PER FOOT WIDTH OF SLAB.

OLD STYLE BAR.

C to C of Bars	½″	¾″	⅞″	1′	1¼″
	□″	□″	□″	□″	□″
2″	1.08	2.22	3.30	4.20	6.43
2½″	0.86	1.78	2.65	3.36	5.14
3″	0.72	1.48	2.20	2.80	4.28
3½″	0.62	1.27	1.89	2.40	3.67
4″	0.54	1.11	1.65	2.10	3.21
4½″	0.48	0.99	1.47	1.86	2.85
5″	0.43	0.89	1.32	1.68	2.57
5½″	0.39	0.81	1.20	1.52	2.34
6″	0.36	0.74	1.10	1.40	2.14
6½″	0.33	0.68	1.02	1.29	1.97
7″	0.31	0.63	0.94	1.20	1.83
7½″	0.29	0.59	0.88	1.12	1.71
8″	0.27	0.55	0.82	1.05	1.60
8½″	0.25	0.52	0.77	0.99	1.51
9″	0.24	0.50	0.73	0.93	1.43
9½″	0.23	0.47	0.69	0.88	1.35
10″	0.22	0.44	0.66	0.84	1.28
11″	0.20	0.40	0.60	0.76	1.17
12″	0.18	0.37	0.55	0.70	1.07
Net Section	0.18	0.37	0.55	0.70	1.07

NEW STYLE BAR.

C to C of Bars	¼″	⅓″	⅜″	½″	⅝″	¾″	⅞″	1″	1¼″
	□″	□″	□″	□″	□″	□″	□″	□″	□″
2″	0.36	0.66	0.84	1.50	2.34	3.36	4.62	6.00	9.37
2½″	0.29	0.53	0.67	1.20	1.87	2.69	3.70	4.80	7.50
3″	0.24	0.44	0.56	1.00	1.56	2.24	3.08	4.00	6.24
3½″	0.21	0.38	0.48	0.86	1.34	1.92	2.64	3.43	5.36
4″	0.18	0.33	0.42	0.75	1.17	1.68	2.31	3.00	4.68
4½″	0.16	0.29	0.37	0.67	1.04	1.49	2.05	2.67	4.16
5″	0.14	0.26	0.34	0.60	0.94	1.34	1.85	2.40	3.75
5½″	0.13	0.24	0.31	0.55	0.85	1.22	1.68	2.18	3.41
6″	0.12	0.22	0.28	0.50	0.78	1.11	1.53	2.00	3.12
6½″	0.11	0.20	0.26	0.46	0.72	1.03	1.42	1.85	2.88
7″	0.10	0.19	0.24	0.43	0.67	0.96	1.32	1.72	2.68
7½″	0.10	0.18	0.22	0.40	0.62	0.89	1.23	1.60	2.50
8″	0.09	0.17	0.21	0.38	0.59	0.84	1.15	1.50	2.34
8½″	0.08	0.16	0.20	0.35	0.55	0.79	1.09	1.42	2.20
9″	0.08	0.15	0.19	0.33	0.52	0.75	1.02	1.33	2.08
9½″	0.08	0.14	0.18	0.32	0.49	0.71	0.97	1.26	1.97
10″	0.07	0.13	0.17	0.30	0.47	0.67	0.92	1.20	1.87
11″	0.07	0.12	0.15	0.27	0.43	0.61	0.84	1.09	1.70
12″	0.06	0.11	0.14	0.25	0.39	0.56	0.77	1.00	1.56
Net Section	0.06	0.11	0.14	0.25	0.39	0.56	0.77	1.00	1.56

UNIVERSAL BAR.

C to C of Bars	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
	□″	□″	□″	□″	□″	□″
2″	1.14	1.92	2.46	3.24	3.90	4.80
2½″	0.91	1.54	1.97	2.59	3.11	3.84
3″	0.76	1.28	1.64	2.16	2.60	3.20
3½″	0.65	1.10	1.41	1.85	2.23	2.74
4″	0.57	0.96	1.23	1.62	1.95	2.40
4½″	0.51	0.85	1.09	1.44	1.73	2.13
5″	0.46	0.77	0.98	1.30	1.55	1.92
5½″	0.41	0.70	0.89	1.18	1.41	1.74
6″	0.38	0.64	0.82	1.08	1.30	1.60
6½″	0.35	0.59	0.76	1.00	1.20	1.47
7″	0.33	0.55	0.70	0.93	1.11	1.37
7½″	0.30	0.51	0.66	0.86	1.04	1.28
8″	0.28	0.48	0.62	0.81	0.97	1.20
8½″	0.27	0.45	0.58	0.76	0.92	1.13
9″	0.25	0.43	0.55	0.72	0.87	1.07
9½″	0.24	0.40	0.52	0.68	0.82	1.01
10″	0.23	0.38	0.49	0.65	0.78	0.96
11″	0.21	0.35	0.45	0.59	0.71	0.87
12″	0.19	0.32	0.41	0.54	0.65	0.80
Net Section	0.19	0.32	0.41	0.54	0.65	0.80

ROUND BAR.

C to C of Bars	⅜″	½″	⅝″	¾″	⅞″	1″	1⅛″	1¼″
	□″	□″	□″	□″	□″	□″	□″	□″
2″	0.66	1.18	1.84	2.65	3.61	4.71	5.96	7.36
2½″	0.53	0.94	1.47	2.12	2.89	3.77	4.77	5.89
3″	0.44	0.79	1.23	1.77	2.41	3.14	3.98	4.91
3½″	0.38	0.67	1.05	1.51	2.06	2.69	3.41	4.21
4″	0.33	0.59	0.92	1.33	1.80	2.36	2.98	3.68
4½″	0.29	0.52	0.82	1.18	1.60	2.09	2.65	3.27
5″	0.26	0.47	0.74	1.06	1.44	1.88	2.39	2.95
5½″	0.24	0.43	0.67	0.96	1.31	1.71	2.17	2.68
6″	0 22	0.39	0.61	0.88	1.20	1.57	1.99	2.45
6½″	0.20	0.36	0.57	0.82	1.11	1.45	1.84	2.27
7″	0.19	0.34	0.53	0.76	1.03	1.35	1.70	2.10
7½″	0.18	0.31	0.49	0.71	0.96	1.26	1.59	1.96
8″	0.17	0.29	0.46	0.66	0.90	1.18	1.49	1.84
8½″	0.16	0.28	0.43	0.62	0.85	1.11	1.40	1.73
9″	0.15	0.26	0.41	0.59	0.80	1.05	1.33	1.64
9½″	0.14	0.25	0.39	0.56	0.76	0.99	1.26	1.55
10″	0.13	0.24	0.37	0.53	0.72	0.94	1.19	1.47
11″	0.12	0.21	0.33	0.48	0.66	0.86	1.08	1.34
12″	0.11	0.19	0.30	0.44	0.60	0.78	0.99	1.22
Net Section	0.11	0.19	0.30	0.44	0.60	0.78	0.99	1.22

Table No. 3.

FLOOR SLABS. ROCK CONCRETE. 1 PER CENT REINFORCEMENT.

TABLE GIVING SAFE LOADS IN POUNDS PER SQUARE FOOT, FOR FLOOR SLABS, CONTINUOUS OVER SUPPORTS, WITH ONE PER CENT OF CORRUGATED BAR REINFORCEMENT. ULTIMATE STRENGTH OF THE CONCRETE TAKEN AS 2500 LBS. PER SQUARE INCH.

Thickness of Slab in Inches.	Area of Steel in 12" Width.	Corresponding Size and Spacing of Corrugated Rounds.		SPAN IN FEET.																	Weight of Slab in Lbs. per Sq. Ft.
		Size.	Spacing.	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
3	0.27□"	⅜" C.R.	5"	525	325	215	145	100	70	....	....	...	...	...	...	...	...	...	...	...	38
3½	0.33□"	⅜" "	4"	810	505	335	235	170	125	90	....	...	...	...	...	...	...	...	...	...	44
4	0.39□"	½" "	6"	1160	720	485	340	250	190	145	110	85	...	...	...	...	...	...	...	...	50
4½	0.45□"	½" "	5½"	1550	970	660	470	345	260	200	155	120	95	...	...	...	...	...	...	...	57
5	0.51□"	½" "	4½"	2000	1260	850	615	455	345	270	210	165	130	105	80	...	...	...	...	...	63
5½	0.57□"	½" "	4"	....	1580	1080	775	575	440	345	270	220	175	140	115	90	...	...	...	...	69
6	0.63□"	⅝" "	6"	....	1950	1335	955	715	550	430	345	275	225	180	150	120	100	...	...	...	75
6½	0.69□"	⅝" "	5½"	....	2370	1620	1165	870	670	525	420	340	280	225	190	155	130	105	...	...	82
7	0.75□"	⅝" "	5"	....	....	1920	1380	1040	805	635	510	410	335	275	230	190	160	135	110	...	88
7½	0.80□"	⅝" "	4½"	....	....	2170	1580	1185	915	725	580	475	395	325	270	220	185	155	130	110	94
8	0.86□"	¾" "	6"	....	....	....	1840	1380	1070	850	685	560	460	385	320	270	225	190	160	135	100
8½	0.92□"	¾" "	5½"	....	....	....	2110	1590	1235	975	790	640	535	445	375	315	265	225	190	165	107
9	0.98□"	¾" "	5½"	....	....	....	....	1810	1410	1115	905	740	615	515	430	365	310	265	230	195	113
9½	1.04□"	¾" "	5"	....	....	....	....	2050	1600	1275	1030	850	700	590	500	420	360	310	265	230	119
10	1.10□"	¾" "	4½"	....	....	....	....	2300	1800	1430	1165	960	795	665	565	485	410	355	305	260	125

Safe loads given are in addition to weight of slab.

For end panels or slabs free at one end, use ⅔ of above loads.
For single panels or slabs free at both ends, use ½ of above loads.

Table No. 4.

FLOOR SLABS, ROCK CONCRETE, .80% REINFORCEMENT.

TABLE GIVING SAFE LOADS, IN POUNDS PER SQUARE FOOT, FOR FLOOR SLABS, CONTINUOUS OVER SUPPORTS, WITH .80 PER CENT OF CORRUGATED BAR REINFORCEMENT, ULTIMATE STRENGTH OF THE CONCRETE TAKEN AS 2000 LBS. PER SQUARE INCH.

Thickness of Slab in inches.	Area of Steel in 12″ width.	Corresponding Size and Spacing of Corrugated Rounds.		SPAN IN FEET.																	Weight of Slab, in lbs. per sq. ft.
		Size.	Spacing.	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
3	0.21□″	⅜″ C.R.	6½″	415	250	160	110	70	50	....	...	...	...	...	...	...	...	...	...	...	38
3½	0.26□″	⅜″ "	5″	635	395	255	175	125	90	60	...	...	...	...	...	...	...	...	...	...	44
4	0.30□″	½″ "	8″	910	565	375	260	190	140	100	75	50	...	...	...	...	...	...	...	...	50
4½	0.35□″	½″ "	7″	1225	765	510	360	260	200	150	110	85	60	...	...	...	...	...	...	...	57
5	0.40□″	½″ "	6″	1600	1000	670	475	350	265	200	155	120	90	70	55	...	...	...	...	...	63
5½	0.45□″	½″ "	5″	2000	1260	850	605	450	340	260	205	160	125	100	80	60	...	...	...	...	69
6	0.49□″	½″ "	4½″	2450	1550	1050	750	560	425	330	260	205	165	130	105	80	65	...	...	...	75
6½	0.54□″	⅝″ "	7″	....	1860	1275	910	680	520	405	320	255	205	165	135	105	85	70	...	...	82
7	0.59□″	⅝″ "	6½″	....	2220	1510	1085	810	620	485	385	310	250	205	165	135	110	90	70	...	88
7½	0.62□″	⅝″ "	6″	....	2600	1715	1235	925	710	555	445	355	290	235	195	160	130	105	85	70	94
8	0.67□″	⅝″ "	5½″	....	....	2000	1450	1090	840	660	525	425	345	285	235	195	160	130	110	90	100
8½	0.72□″	¾″ "	7½″	....	....	2300	1670	1250	970	760	610	495	405	335	280	230	190	160	130	110	107
9	0.76□″	¾″ "	7″	....	....	2600	1900	1430	1110	870	700	570	470	385	325	270	225	190	160	135	113
9½	0.81□″	¾″ "	6½″	....	....	....	2140	1610	1260	990	800	650	540	445	370	310	265	220	190	160	119
10	0.86□″	¾″ "	6″	....	....	....	2400	1815	1410	1115	900	735	610	505	430	360	305	255	220	185	125

Safe loads given are in addition to weight of slab.

For end panels or slabs free at one end, use ⅔ of above loads.
For single panels or slabs free at both ends, use ½ of above loads.

Table No. 5.

FLOOR SLABS, CINDER CONCRETE, .46% REINFORCEMENT.

TABLE GIVING SAFE LOADS IN POUNDS PER SQUARE FOOT, FOR FLOOR SLABS, CONTINUOUS OVER SUPPORTS WITH .46 PER CENT OF CORRUGATED BAR REINFORCEMENT. ULTIMATE STRENGTH OF THE CONCRETE TAKEN AS 750 POUNDS PER SQUARE INCH.

Thickness of Slab in Inches	Area of Steel in 12″ Width	Corresponding Size and Spacing of Corrugated Rounds.		SPAN IN FEET													Weight of Slab in lbs. per sq. ft.
		Size.	Spacing.	4	5	6	7	8	9	10	11	12	13	14	15	16	
3	0.13□″	⅜″C.R.	10″	220	130	80	50	...	...	...	...	...	...	...	...	...	28
3½	0.15□″	⅜″ "	9″	340	205	130	90	60	...	...	...	...	...	...	...	...	33
4	0.18□″	⅜″ "	7½″	495	300	195	130	90	60	...	...	...	...	...	...	...	38
4½	0.21□″	½″ "	11″	660	410	280	185	130	95	70	50	...	...	...	...	...	42
5	0 24□″	½″ "	10″	855	530	355	250	175	130	95	70	50	...	...	...	...	47
5½	0.27□″	½″ "	8½″	1080	675	450	315	230	170	130	95	70	55	...	...	...	52
6	0.29□″	½″ "	8″	1330	830	560	395	290	215	165	125	95	75	55	...	...	56
6½	0.32□″	½″ "	7½″	....	1000	680	480	350	270	200	160	120	95	75	55	...	61
7	0.35□″	½″ "	7″	....	....	800	575	420	325	250	195	150	115	95	75	55	66
7½	0.37□″	½″ "	6½″	....	....	....	660	490	370	290	225	175	140	110	85	70	70
8	0.40□″	½″ "	6″	....	....	....	...	570	435	335	265	210	165	135	105	85	75

Safe loads given are in addition to weight of slab. For end panels or slabs free at one end use ⅔ of above loads. For single panels or slabs free at both ends use ½ of above loads.

Table No. 6.

ROCK AND CINDER CONCRETE SLABS, USING EXPANDED METAL.

TABLE GIVING SAFE LOADS IN POUNDS PER SQUARE FOOT FOR FLOOR SLABS INCORPORATED INTO PANELS, WHEN REINFORCED WITH NO. 10 GA., 3″ MESH, EXPANDED METAL.

ROCK CONCRETE						CINDER CONCRETE					
Thickness of Slab in Inches	SPAN IN FEET					Thickness of Slab in Inches	SPAN IN FEET				
	4	5	6	7	8		4	5	6	7	8
2½	350	250	170	120	90	2½	250	170	110	80	...
3	475	300	200	150	100	3	390	240	165	120	80
3½	570	350	250	175	125	3½	510	325	220	155	110
4	650	420	280	200	140	4	600	380	260	180	135
4½	750	470	325	225	160	4½	690	430	290	210	150
5	840	520	350	250	185	5	775	490	330	230	175
5½	920	580	390	280	210	5½	860	540	360	260	195
6	1000	650	440	310	225	6	950	600	400	290	210

Safe loads given are in addition to weight of slab.

Table No. 7.

TABLE GIVING SAFE LOADS, PER FOOT RUN, FOR REINFORCED CONCRETE BEAMS, ONE INCH WIDE, FREE AT THE ENDS, WHEN REINFORCED WITH GIVEN AREAS OF CORRUGATED BAR REINFORCEMENT.

Total Depth of Beam *h.*	Effective Depth of Beam *d.*	Area of Metal per in. of Width	SPAN IN FEET.																
			10	11	12	13	14	15	16	17	18	19	20	21	22	24	26	28	30
		□″																	
12	10	0.122	88	72	60	...	...	...	...	...	...	...	...	...	...	...	..	..	..
13	11	0.135	108	88	73	61	...	...	...	...	...	...	...	...	...	...	..	..	..
14	12	0.147	130	106	88	74	63	...	...	...	...	...	...	...	...	...	..	..	..
15	13	0.159	153	125	104	87	74	63	...	...	...	...	...	...	...	...	..	..	..
16	14	0.172	178	146	121	102	87	75	65	...	...	...	...	...	...	...	..	..	..
17	15	0.184	205	168	140	117	100	86	75	65	...	...	...	...	...	...	..	..	..
18	16	0.196	234	192	160	135	115	99	86	75	66	...	...	...	...	...	..	..	..
19	17	0.208	265	217	181	153	130	112	97	85	75	66	...	...	...	...	..	..	..
20	18	0.221	297	244	204	172	147	126	110	96	85	75	66	...	...	...	..	..	..
21	19	0.233	333	273	228	193	164	142	123	108	95	85	75	67	...	...	..	..	..
22	20	0.245	370	303	253	214	183	158	137	120	106	94	84	75	67	...	..	..	..
23	21	0.257	...	336	279	237	202	175	152	133	117	104	93	83	75	...	..	..	..
24	22	0.269	...	...	307	261	223	192	167	147	130	115	102	91	82	67	..	..	..
26	24	0.294	...	...	...	311	267	230	200	177	155	138	123	110	99	81	67	..	..
28	26	0.319	...	...	...	...	314	271	236	208	184	163	146	131	118	97	80	67	..
30	28	0.343	...	...	...	...	...	316	276	243	215	191	171	154	139	114	95	79	67

For beams continuous over supports increase above loads 50%.

The safe loads given are in addition to the weight of the beams.

Simple Beams.—Below the stepped line the loads for beams free at the ends will not cause an average end shear greater than 80 pounds per square inch.

Continuous Beams.—Above the stepped line the loads for continuous beams will not cause an average end shear greater than 80 pounds per square inch.

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